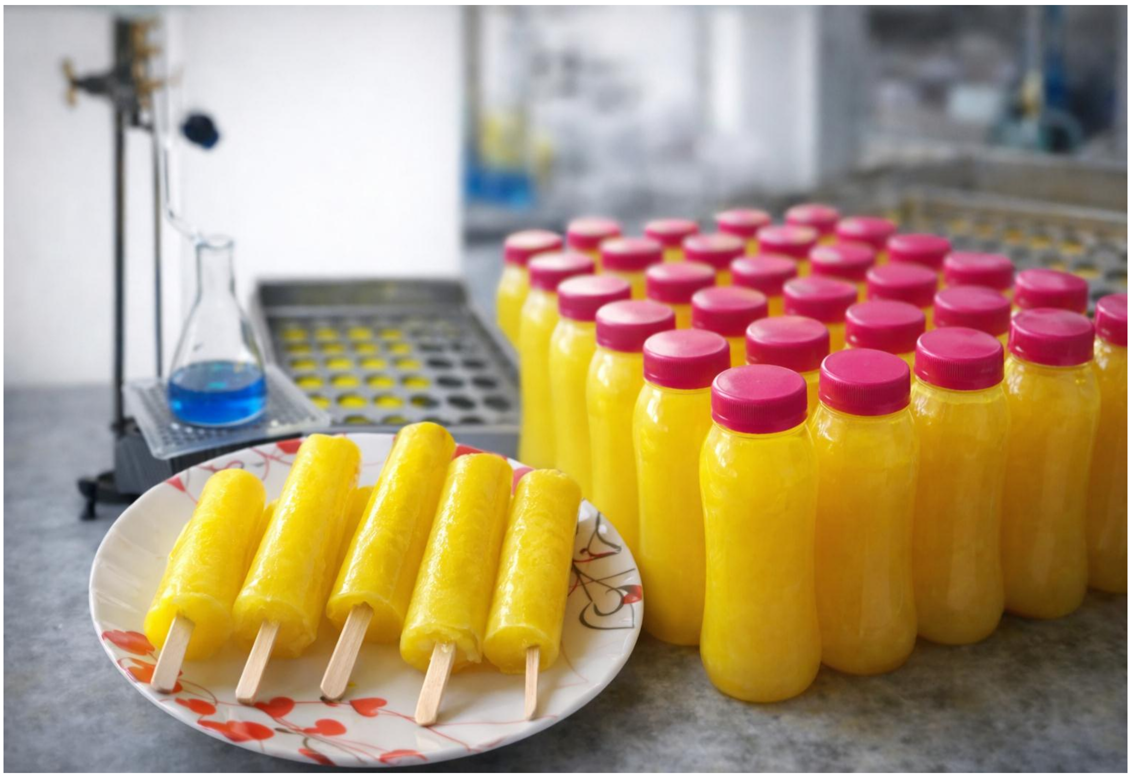
Feasibility Study For Innovative Dairy Product Development

(Whey Based Product)



National Dairy Development Board

Lalitpur, Nepal

July 2026

FOREWORD

The study, **Feasibility Study for Innovative Dairy Product Development (Whey-Based Products)** was undertaken by the National Dairy Development Board (NDDB) through research conducted across the Koshi and Bagmati Provinces. The dairy sector is a key contributor to Nepal's economy, contributing nearly 23.93% of livestock's share to AGDP (2081/82) while raw milk production contributes approximately 11.83% of AGDP supporting the livelihoods of thousands of farming households. With the increasing demand for processed dairy products such as cheese, paneer, and chhurpi, the generation of whey as a by-product has also increased.

Despite its rich nutritional value, whey is often treated as waste, leading to environmental concerns and the loss of valuable resources. Much of this whey is discharged without treatment, highlighting the need for sustainable utilization. Recognizing this opportunity, NDDB conducted this study to evaluate the physicochemical properties of whey and explore its commercial potential. It is encouraging that the study has successfully developed the feasibility of two value-added products: whey lolly and a pineapple-flavoured whey beverage**,** both demonstrating promising potential for commercial production.

This study marks an important step toward transforming whey from a waste product into a valuable resource. The outcomes of this study provide a strong foundation; however, further research is necessary to optimize the formulations, improve product quality, and assess long-term commercial feasibility. I believe that its findings will encourage dairy industries, cooperatives, and private-sector stakeholders to adopt sustainable whey utilization practices, contributing to environmental protection, increased rural income, and the long-term growth of Nepal's dairy sector.

I appreciate the study team's dedication in collecting samples, optimizing product formulations, conducting sensory evaluations, and assessing product safety and shelf life. I also extend my sincere appreciation to Technical Director Dr. Hasana Maiya Shrestha**,** Senior Food Research Officer Dr. Huma Kumari Bokhim**,** Assistant Professor Sudip Pokhrel , Research Officer Narayan Deshar**,** and Research Assistants Namuna Khatiwada and Sudhi Singh for their significant contributions to field research, laboratory analysis, and product development.

On the behalf of the National Dairy Development Board, I thank the study team, participating dairy industries, and all those who contributed to the successful completion of this important work.

Dr. Balak Chaudhary
Acting Executive Director

ABSTRACT

Whey is the largest by-product generated during the manufacture of cheese, paneer, and chhurpi, containing nearly 50% of the original milk nutrients, including whey proteins, lactose, minerals, and water-soluble vitamins. In Nepal, large quantities of whey are discarded without treatment, resulting in environmental pollution because of its high biological oxygen demand. This study was conducted to evaluate the physicochemical characteristics of different whey types produced in Nepal and to assess the feasibility of converting whey into value-added products through the development of whey lolly and pineapple-flavoured whey beverage.

A total of 55 whey samples were collected from cheese, paneer, and chhurpi industries located in 11 districts of Koshi and Bagmati Provinces. Annual whey generation from major dairy industries was estimated at 75,452 metric tons, produced from 83,286 metric tons of milk processed into cheese, paneer, and chhurpi. Chhurpi industries alone generated 36,473 MT (48.3%) of the total whey, followed by the Nepal Dairy Association (29,554 MT). These findings indicate that whey is one of the largest underutilized dairy resources in Nepal with significant potential for value addition.

The collected whey samples were analyzed for fat, solids-not-fat (SNF), total solids (TS), acidity, pH, total soluble solids (TSS), reducing sugar, and protein. Considerable variation was observed among different whey types. Mozzarella whey contained the highest fat **(**0.98%**)** and protein (1.13%), while yak cheese whey recorded the highest SNF (7.47%)**,** total solids (7.93%)**,** TSS (5.94%), and reducing sugar (3.95%). Paneer whey exhibited the highest acidity (0.27%) with the lowest pH (4.98), whereas chhurpi whey contained the lowest fat (0.08%) and protein (0.51%). These differences were mainly attributed to milk composition, coagulation methods, and cheese-making technology.

Citric acid and acetic acid were evaluated as coagulants for paneer whey preparation. Citric acid was selected because it produced a clean flavour suitable for product development, while acetic acid imparted an undesirable pungent taste. Based on sensory evaluation, the optimized whey lolly formulation consisted of 500 g whey, 81 g sugar, 21.42 g glucose syrup, 2.5 g stabilizer/emulsifier, 1.5 g citric acid, 0.25 g colour, and 2.25 g pineapple flavour. Similarly, the optimum pineapple-flavoured whey beverage contained 450 g whey, 50 g pineapple juice, 50 g sugar, 0.75 g stabilizer/emulsifier, and 0.1 g colour, providing the highest overall sensory acceptability.

The chemical composition of the optimized whey lolly revealed 0.40% fat, 21.70% total solids, 21.00% total soluble solids, 0.384% acidity (as citric acid), pH 4.0, 0.32% protein, and 4.42% reducing sugar. The production cost was calculated at NRs. 4.07 per 35 g lolly, indicating good commercial feasibility.

The optimized pineapple-flavoured whey beverage contained 0.40% fat, 16.00% total solids, 15.60% total soluble solids, 0.20% acidity (as citric acid), pH 4.2, 0.30% protein, 2.69% reducing sugar, and 0.08% total ash **.**

Microbiological analysis showed an initial total bacterial count of 4.5×10^1 CFU/ml, while coliforms and yeast/mold were absent. Shelf-life studies demonstrated that the beverage remained microbiologically safe for 60 days under refrigeration (4–8°C) and 30 days at room temperature. The production cost was estimated at NRs. 20.61 per 200 ml bottle, indicating promising commercial potential.

The study concludes that whey is a valuable nutritional resource rather than a waste product. The successful development of whey lolly and pineapple-flavoured whey beverage demonstrates the technical feasibility of transforming whey into safe, nutritious, and economically viable products. Adoption of whey utilization technologies can substantially reduce environmental pollution, improve resource efficiency, increase income for dairy processors, and promote sustainable dairy development and a circular bio economy in Nepal.

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ABBREVIATION

AGDP	Agricultural Gross Domestic Product
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
SNF	Solids-Not-Fat
TS	Total Solids
TSS	Total Soluble Solids
TPC	Total Plate Count (or Total Bacterial Count)
CFU	Colony Forming Unit
GDP	Gross Domestic Product
DDC	Dairy Development Corporation
NDA	Nepal Dairy Association
DIA	Dairy Industry Association
NDDB	National Dairy Development Board
FAO	Food and Agriculture Organization
AOAC	Association of Official Analytical Collaboration (formerly Association of Official Analytical Chemists)
BIS	Bureau of Indian Standards
NBS	Nepal Bureau of Standards
CMC	Carboxy Methyl Cellulose
BCAAs	Branched-Chain Amino Acids
DE	Dextrose Equivalent
INS	International Numbering System for Food Additives
RSM	Response Surface Methodology
SPSS	Statistical Package for the Social Sciences
NPR	Nepalese Rupee
NRs.	Nepalese Rupees
MT	Metric Ton
pH	Measure of acidity or alkalinity
°C	Degrees Celsius
g	Gram
kg	Kilogram
ml	Millilitre
L	Litre.
%	Percentage
Brix	Measurement of total soluble solids, mainly sugars.

CHAPTER I: INTRODUCTION

1.1 Background

About 57.3 % of total population in Nepal is engaged in agriculture. Agriculture contributes about 24% on Gross Domestic Products and livestock sector contribute about 23.93% on AGDP (Economic survey 2081/82). Dairy sector remains a cornerstone of Nepal's economy. Raw milk of cow and buffalo together contributes 11.83% on AGDP (Statistical Information on Nepalese agriculture 2081/82). This subsector plays an instrumental role in reducing poverty through employment and income generation. It also ensures regular flow of income from urban to rural areas. More than half a million households are engaged in the production and marketing of milk in the formal milk market, yet less than 20% of total annual milk produced enters the formal market.

Milk processing industries in Nepal are expanding rapidly due to urbanization and growing demand for processed milk and dairy products, though a significant deficit exists between installed processing capacity and available raw milk. In order to achieve national self-sufficiency in milk, the government has intended to increase the volumes of milk entering the formal market through improved milk production and animal productivity.

With rapid urbanization, increased incomes, dietary diversification, and remittance-driven consumption, demand for milk and milk products is growing at an accelerating rate. Beyond fluid milk, dairy industries are processing substantial quantities of raw milk into products such as yoghurt, cheese, paneer, khowa, ice cream, butter, chhurpi, and ghee. Demand for both domestic and export markets are rising year by year.

In Nepal, chhurpi production and exports are experiencing significant growth, with exports reaching NPR 4.51 billion in fiscal year 2024/25 a volume of 2610 MT, marking a 41% increase over the previous year. Nepal produces an estimated 656 metric tons of cheese annually, with approximately 4% of raw milk in the formal sector being diverted to paneer production.

Whey is the largest by-product of the dairy industry by both volume and milk solids. It contains approximately 50% of the original milk solids, including whey proteins, lactose, minerals, water-soluble vitamins, and residual lipids. Whey can be defined as the watery, thin liquid fraction of milk obtained after the removal of casein curd, which separates due to the action of the enzyme chymosin (rennet) or mineral/organic acids (Zadow, 1994). Transformation of whey into value-added products whey protein concentrate, whey powder, lactoalbumin, lactoglobulin, beverages, and single-cell protein helps maximize the utilization of its precious constituents (Caric and Milanovic, 1995).

1.2 Statement of the Problem

Dairy industries are major users of water and generators of waste water. The volume, concentration, and composition of dairy effluents depend on the type of product processed, production schedules, operating methods, and the degree of water management applied. When whey is discharged untreated into water bodies, its high organic matter content creates a biological oxygen demand (BOD) of 30–40 g of oxygen per litre. The pollution load from a cheese factory processing 100,000 litres of milk per day would be equivalent to the sewage output of a city of 60,000 inhabitants (Petillot, 1976).

Currently, DDC, NDA, DIA, and the Himalayan Cheese Industry Association are the major stakeholders for cheese, paneer, and chhurpi production in Nepal. In fiscal year 2024/25, these organizations collectively produced around 5436 metric tons of cheese, chhurpi, and paneer, generating an estimated 75452 metric tons of whey (NDDB, 2026). Despite the nutritional value of whey, some dairies supply it to pig farmers in eastern Nepal, while others drain it increasing pollution loads in sewage systems and water bodies.

To address the dual challenges of environmental pollution and missed nutritional and economic opportunity, it is strongly recommended that the dairy sector develop and market whey-based products such as beverages, lollies, and other value added foods.

1.3 Objectives of the Study

The general objective of this study is to assess the feasibility of dairy product development based on whey. The specific objectives are:

- To analyze the physicochemical parameters (colour, smell, taste, fat, SNF, TSS, total solids, protein, and acidity) of whey and whey-based dairy products.
- To prepare whey-based dairy products (whey lolly and pineapple-flavoured whey beverage).
- To identify the shelf life of prepared whey-based dairy products in terms of sensory attributes (smell, taste, colour) and microbiological indicators (TPC and yeast/mold count).
- To assess the scalability and economic aspects of operation for whey-based product development.

1.4 Rationale of the Study

This study is aimed at the proper utilization of whey through the preparation of whey lolly and pineapple-flavoured whey beverage incorporating pineapple juice, sugar, colour, and stabilizer and emulsifier to address both the whey disposal problem and the opportunity for value-added product development. A wide variety of ailments, including anemia, arthritis, and liver disorders, may be alleviated through whey consumption, which also possesses preventive and curative properties (Jelen, 1991). Whey protein has high nutritive value, providing all essential amino acids as well as most minerals important for tissue growth and repair, regulation of muscle protein synthesis, and glucose homeostasis (Irena et al., 2008).

The increasing demand for soft drinks and refreshing beverages during summer months can be partially met by fruit-based whey beverages. The development of value-added fruit and whey beverages also reduces post-harvest loss of fruits (Prendergast, 1985). At present, fruit beverages available on the Nepali market are largely ready-to- beverages which may or may not contain food additives such as synthetic colours and flavours. A blend of whey with pineapple pulp would yield a value-added, nutritious product for human consumption in place of a waste stream currently discharged into water bodies.

1.5 Coverage of the Study

Whey samples were collected purposively from districts where raw milk is processed into cheese, paneer, and chhurpi. Based on the concentration of production activities, the study covered the following districts:

- Koshi Province: Solukhumbu, Ilam, and Jhapa
- Bagmati Province: Dolakha, Ramechhap, Kavre, Nuwakot, Makawanpur, Rasuwa, and Kathmandu Valley

1.6 Limitation of the study

The current study has following limitations**.**

- **Limited geographical coverage:** The study included 11 districts from Koshi and Bagmati provinces only. Findings may not represent whey characteristics from other major dairy-producing provinces of Nepal.
- **Sample size limitations:** A total of 55 whey samples were analyzed, with unequal representation among whey types. A larger and more balanced sample size would improve the reliability of comparisons.
- **Seasonal variation not controlled:** Differences in feed, lactation stage, and milk composition across seasons were not systematically accounted for, which may have influenced the physicochemical properties of whey.
- **Limited product development:** The study developed only two whey-based products (whey lolly and pineapple-flavoured whey beverage). Other potential value-added products were not investigated.
- **Shelf-life study constraints:** Shelf-life evaluation was limited to refrigerated and room-temperature storage for up to 75 days. Advanced preservation methods and repeated sensory evaluations throughout storage were not included.

- **Economic assessment:** The economic analysis was qualitative. Detailed cost-benefit analysis, investment requirements, break-even analysis, and return on investment were beyond the scope of the study.
- **Consumer acceptance:** Sensory evaluation was conducted using trained and semi-trained panelists only. Consumer acceptance, willingness-to-pay, and market validation under real retail conditions were not assessed.
- **Microbiological limitations:** Microbiological testing was limited to Total Bacterial Count, coliforms, and yeast/mold. Pathogen-specific analyses and detailed spoilage organism identification were not performed.

CHAPTER II: LITERATURE REVIEW

2.1 Whey

Whey is the liquid fraction remaining after coagulation and separation of casein during the manufacture of cheese, paneer, chhurpi, casein, and related dairy products. It appears as a greenish, translucent liquid that separates from clotted milk. Traditionally considered a by-product of dairy processing, whey is now recognized as a nutritionally rich raw material with wide applications in functional foods, beverages, nutraceuticals, and value-added dairy products. Approximately five to nine litres of whey are generated per kilogram of cheese produced. Whey contains approximately 6.0–6.5% total solids, 4.5–4.8% lactose, and 0.7–0.8% whey proteins (Adhikari, 2005).

Whey contains high organic matter and thus constitutes a potential pollutant when discharged untreated, creating a biological oxygen demand of 35–45 kg per litre. A small cheese factory producing 4,000 litres of whey per day generates a pollution load equivalent to the sewage output of 1,900 people (Tunick, 2008). Over the past two decades, whey has transitioned from a waste product to a high-value ingredient used in infant formulas, food supplements, sports bars, and beverages (Marshall, 2004).

2.2 History of Whey

The history of whey is inseparable from the history of cheese, as whey is produced as a natural by-product of the cheese-making process. Whey was originally discovered by accident when milk soured and curds and whey separated naturally the curds becoming the earliest cheeses. The use of whey dates back several centuries, with historical records indicating its consumption in ancient Greece and Rome as a health-promoting drink.

During the eighteenth and nineteenth centuries, "whey cures" became popular across Europe, where whey was prescribed for digestive disorders and general wellness. Hippocrates (446–337 BC) and Galen (200–131 BC) both recommended whey to their patients. In 1749, a notable account from Zurich, Switzerland, recorded a patient healed by drinking whey at the village of Gais. This event sparked widespread interest, eventually leading to the establishment of more than 160 whey spas across Switzerland, Austria, and Germany, frequented by European emperors and aristocrats (Vasey, 2006).

Despite its historical medicinal value, whey was primarily regarded as waste by the dairy industry until late in the twentieth century, when regulations prevented untreated disposal. Concurrently, advances in food science began to reveal the nutritional and functional value of whey components, establishing a scientific basis that continues to expand through the early twenty-first century (Smithers, 2008).

2.3 Classification of whey

2.3.1 Classification of whey according to acidity and pH

- Sweet Whey: Produced from chymosin-coagulated cheeses with a low level of acidity (e.g., Cheddar). Titratable acidity ranges from 0.1–0.2% with pH 5.0–6.6 (Zadow, 2003).
- Medium Acid Whey: Derived from the manufacture of fresh acid cheeses such as Ricotta or Cottage cheese. Titratable acidity ranges from 0.20–0.40% with pH 5.0–5.8 (Zadow, 2003).
- Acid Whey: Produced from casein manufacture using mineral acids, or from some fresh acid cheese processes. Titratable acidity exceeds 0.40% with pH below 5.0 (Zall, 1984).

Table 1: Composition of different whey types

Constituents	Cheddar Cheese	Acid Casein	Rennet Casein	Chhana & Paneer	Co-precipitates
Total Solids (%)	6.7	6.9	6.7	6.4	6.1
Fat (%)	0.3	0.1	0.1	0.5	0.1
Protein (%)	0.9	1.0	1.0	0.4	0.3
Lactose (%)	4.9	5.1	5.1	5.0	5.1
Ash (%)	0.6	0.7	0.5	0.5	0.6
Titratable Acidity (%)	0.2	0.4	0.2	0.4	0.3

(IDA, 2007)

Note: Whey from different product categories cheese, casein, chhana, paneer, and co-precipitates varies considerably in chemical composition and acidity. In general, whey contains about half of the total solids of milk, including lactose, whey proteins, minerals, and vitamins. Whey proteins, though present in small quantities, have a high protein efficiency ratio (3.6), biological value (104), and net protein utilization (95%), and rank second only to egg protein in nutritive value.

2.3.2 Classification of whey in the Nepali context

According to the milk used for the product preparation Nepalese whey can be classified into yak cheese whey, kanchan cheese whey, mozzarella cheese whey, paneer whey and chhurpi whey. The composition of whey depends on the type of milk used, the cheese-making process, and the coagulation method. Generally, whey contains approximately 93–94% water, 4.5–5.0% lactose, 0.6–1.0% protein, 0.2–0.5% fat, and 0.5–0.8% minerals (Table 2). About 50–55% of the nutrients present in milk are retained in whey after curd formation (Foods, 2025).

Table 2: Chemical composition of Nepalese whey

Whey Type	Lactose (%)	Protein (%)	Fat (%)	Minerals (%)	Whey Type
Yak cheese whey	4.5–5.0	0.8–1.0	0.3–0.6	0.6–0.8	Sweet
Kanchan cheese whey	4.8–5.0	0.7–0.9	0.2–0.5	0.5–0.7	Sweet
Mozzarella whey	4.5–5.0	0.7–0.9	0.2–0.4	0.6–0.8	Sweet
Paneer whey	4.5–5.0	0.6–0.8	0.2–0.4	0.7–1.0	Acid
Chhurpi whey	4.0–4.8	0.7–1.0	0.2–0.5	0.8–1.2	Acid

Shrestha et al. (1997); De (2001); Fox et al. (2015); Lagrange et al. (2009); Puranik et al. (2021).

2.3.2.1 Yak cheese whey

Yak cheese is traditionally produced from yak or Chauri milk in the Himalayan regions of Nepal. Yak milk contains higher total solids (19.3%), protein (5.5%), and fat (7–10%) than cow milk. Consequently, yak cheese whey contains relatively higher concentrations of whey proteins, minerals, and residual fat compared with conventional cow milk whey. The whey is classified as sweet whey because cheese manufacture involves rennet coagulation. (Neupaney et al,1997). Yak cheese whey typically contains 92–93% water, 4.5–5.0% lactose, 0.8–1.0% protein, 0.3- 0.6% fat and 0.6-0.8% ash (Shrestha et al., 1997).

2.3.2.2 Kanchan cheese whey

Kanchan cheese is a semi-hard cow milk cheese produced by Nepal's dairy industry. Since it is manufactured using rennet coagulation, the resulting whey is sweet whey. Its composition is similar to that of Gouda-type cheese whey, containing lactose as the major solid constituent and moderate amounts of whey proteins and minerals. (Mc Sweeney et al. 2017). It contains about 93–94% water, 4.8–5.0% lactose, 0.7–0.9% protein, 0.2–0.5% fat and 0.5–0.7% minerals (Molea et al, 2013).

2.3.2.4 Mozzarella cheese whey

Mozzarella whey is also classified as sweet whey, although it possesses somewhat higher mineral and lactate contents than many other sweet wheys. Its pH is approximately 6.3–6.4. Due to starter culture activity during cheese production, mozzarella whey may contain appreciable amounts of galactose and lactate in addition to lactose (Prazeres, (2009). It contains about 93% water, 4.5-5.0% lactose, 0.7- 0.9% protein, 0.2-0.4% fat and 0.6-0.8% minerals (Smithers, G.W. 2008).

2.3.2.5 Paneer whey

Paneer whey is an acid whey produced by coagulating heated milk with citric acid, lactic acid, or lemon juice. The lower pH causes greater solubilization of calcium and phosphate from casein micelles into the whey, resulting in higher mineral content than sweet whey. Paneer whey is rich in lactose, soluble proteins, calcium, phosphorus, and B-complex vitamins. (Puranik et al., 2021; De, 2001; Fox et al., 2015). Paneer whey typically contain 93–94% water, 4.5–5.0% lactose, 0.6–0.8% protein, 0.2–0.4% fat and 0.7–1.0% minerals (De, 2001; Puranik et al., 2021; Kumar et al., 2022).

2.3.2.6 Chhurpi whey

Chhurpi is a traditional Himalayan acid-coagulated cheese made mainly from yak or Chauri milk. Sour whey from previous batches is often used as the acidifying agent, creating a highly acidic environment (pH about 3.8–4.2). Chhurpi whey therefore contains elevated mineral levels, organic acids, and residual whey proteins. Because yak milk is rich in protein and fat, chhurpi whey is nutritionally valuable despite being a by-product (Chhurpi.org, 2025a; Chhurpi.org, 2025b; Chhurpi.org, 2025c). It contain about 92–94% water, 4.0–4.8% lactose, 0.7–1.0% protein, 0.2–0.5% fat and 0.8–1.2% minerals (Foods, 2025).

2.4 Nutritional Composition of whey

Whey proteins mainly β-lactoglobulin, α-lactalbumin, bovine serum albumin, and immunoglobulins possess excellent nutritional and functional properties. These proteins exhibit high digestibility and biological value, and are recognized for their antioxidant, antimicrobial, and immune-enhancing properties (Legarova and Kourimska, 2010).

The major nutritional components of whey include:

- Proteins: β-lactoglobulin, α-lactalbumin, immunoglobulins, serum albumin, and lactoferrin
- Carbohydrates: Lactose (composed of glucose and galactose)
- Minerals: Calcium, phosphorus, potassium, magnesium, sodium, and zinc
- Vitamins: Riboflavin (B2), thiamine (B1), pyridoxine (B6), and cobalamin (B12)

2.5 Utilization of Whey

The increasing demand for functional foods and beverages has stimulated interest in whey as a base ingredient for novel dairy products. Converting whey into value-added products not only reduces environmental pollution but also improves the profitability of dairy processing. Galactose a unique carbohydrate component of lactose found only in milk is a readily digestible carbohydrate critical to infant brain development (cerebroside synthesis), underscoring the importance of its recovery and utilization.

Major whey utilization pathways include thermal condensing, membrane processing (ultrafiltration, nano filtration, and reverse osmosis), spray drying, crystallization, fermentation, and hydrolysis. These yield products such as condensed whey, whey powder, demineralized whey powder, whey protein concentrates, lactose, calcium phosphate, whey beverages, whey cheeses, and permeate.

Table 3: Comparison of whey processing methods

Method	Purpose	Advantages	Challenges	Applications
Spray Drying	Convert liquid whey to powder	Long shelf life, easy transportation	High energy consumption (~5,000 kJ/kg)	Powdered milk, protein supplements
Ultrafiltration	Separate protein and lactose	Produces high-protein concentrates	Requires advanced equipment (membrane fouling risks)	Functional foods, sports nutrition drinks
Nanofiltration	Extract salts and lactose	Enhances product purity	High initial setup costs	Lactose-free products, infant formulas
Reverse Osmosis	Reduce water content	Energy-efficient, reduces transport costs	Limited to pre-filtered whey streams	Pre-concentration for drying

(Mirzakulova et al., 2025)

Table 4: Functional whey -based beverage categories

Beverage Type	Dominant Functional Component	Target Consumer	Processing Technology	Sensory Profile
Probiotic (e.g., whey kefir)	Probiotics (Lactobacillus, Bifidobacterium)	Gut microbiota support	Fermentation with starter cultures	Sour, refreshing, lightly carbonated
Amino acid-enriched	BCAAs, leucine, glutamine	Athletes and physically active individuals	Ultrafiltration + amino acid fortification	Neutral, milky, slightly sweet
Mineral–Vitamin drink	Calcium, magnesium, vitamins B, D, E	Seniors and individuals with deficiencies	Mineral enrichment + spray drying	Delicate, mildly sweet, herbal or mineral-like
Herbal whey beverage	Polyphenols, flavonoids, essential oils	Natural/plant-based consumers	Herbal infusion + pasteurization	Botanical, slightly astringent, aromatic
Goat whey drink	Medium-chain fatty acids, cysteine	Infants, children, casein intolerant	Enzymatic hydrolysis + composition standardization	Mild, slightly sweet, smooth
Energy drink	Caffeine, taurine, amino acids	Young adults, students	Protein isolation + concentration + extracts	Intense, stimulating, citrus-like

(Mirzakulova et al., 2025)

2.5.1 Whey-Based Ice Lollies

Ice lollies are frozen products prepared from flavoured liquids and are popular among consumers for their refreshing nature and affordability. Whey can serve as a base material in ice lolly production owing to its nutritional composition and functional properties (Smithers, 2008; Prazeres et al., 2012). Traditional ice lollies are composed primarily of water, sugar, flavouring agents, and colouring materials. Replacing water partially or fully with whey improves nutritional value by incorporating proteins, lactose, minerals, and vitamins (Pescuma et al., 2010; Smithers, 2008).

Fruit flavours such as pineapple, mango, strawberry, orange, and mixed fruit have been successfully incorporated into whey ice lollies. The addition of fruit juice enhances taste, colour, and aroma while increasing vitamin and antioxidant content (Jelen, 2003; Yadav et al., 2015). Stabilizers are generally added to improve texture, sweetness, and melting characteristics in frozen dairy desserts (Marshall et al., 2003). Utilizing whey in frozen products presents an economically viable strategy for dairy industries to transform a low-value by-product into a profitable functional food product (Prazeres et al., 2012; Smithers, 2008).

Singh and Broadway (2008) studied the optimization of whey-based ice lolly as a value-added dairy product. Whey proteins, being easily digestible, possess excellent therapeutic properties. The study investigated the replacement of water with whey in ice lolly and partial substitution of sucrose with 42 DE corn syrup. Results indicated that viscosity increased gradually with higher corn syrup levels. Sensory evaluation revealed that Treatment T2 (10% corn syrup substitution for sugar) was most acceptable for colour, taste, flavour, and appearance.

Parmar et al. (2017) studied the utilization of paneer whey in ice candy-type frozen desserts. The optimized product showed approximately 0.53% acidity and 32°Brix total soluble solids, with improved flavour and texture compared to the control. The study concluded that paneer whey can effectively replace water to produce an acceptable frozen dairy product with commercial potential.

Chavan et al. (2020) developed whey ice candy enriched with fruit pulp. Formulations were optimized using Response Surface Methodology, with pineapple-flavoured whey ice candy achieving the highest acceptability. The optimized product demonstrated favourable sensory attributes and remained acceptable during frozen storage for up to 60 days.

Gajo et al. (2017) investigated the influence of hydrocolloid stabilizers — including guar gum, xanthan gum, and carrageenan — on concentrated whey popsicles. These significantly improved viscosity, melting resistance, and sensory quality. Stabilizer selection was identified as critical for achieving desirable texture and product stability.

Kaminska-Dworznicka et al. (2021) evaluated the effects of stabilizers on whey-based frozen dairy products and observed improvements in viscosity, structural stability, and resistance to ice recrystallization during storage. Among the tested stabilizers, iotacarrageenan produced superior quality retention, emphasizing the importance of stabilizer optimization for shelf life and quality.

2.5.2 Whey-Based Beverages

Whey-based beverages are among the most promising products derived from dairy by-products. Their high nutritional value, refreshing taste, and low production cost make them attractive alternatives to carbonated soft drinks. Whey can be blended with fruit juices, fruit pulps, natural flavours, and sweeteners to improve sensory acceptance and nutritional quality.

Pious et al. (2025) developed a pineapple-based whey beverage enriched with banana pseudo-stem extract and ginger. Formulation was optimized using Response Surface Methodology (RSM), demonstrating feasibility in creating a nutritious and sustainable product that minimizes food waste while enhancing sensory appeal.

Pandey et al. (2019) noted that whey-based beverages are a promising option for shelf-stable beverages with high nutraceutical potential. Pineapple, being rich in vitamin C, fibre, and digestive enzymes, stimulates digestion and proper functioning of the small intestine and kidneys, and has known anti-constipation and microbiome-normalizing effects.

Shukla et al. (2013) developed a probiotic beverage using whey and pineapple juice, with Lactobacillus acidophilus as the probiotic organism. A 65:35 blend of whey to pineapple juice with 1% inoculum produced a satisfactory product with a shelf life of 24 days at 5 ± 1°C and 48 hours at 30 ± 1°C.

Djuric et al. (2004) identified citrus and tropical fruits as most suitable for combination with whey drinks, as these efficiently reduce undesirable odour and salty-sour flavour characteristics of fresh whey. Pineapple micronutrients are also associated with reduced risk of certain cancers and cardiovascular and neurological diseases.

Kapil Kumar et al. developed a whey-based beverage from pineapple pulp combined with edible extract of medicinal plant *Mentha arvensis*, producing a beverage with excellent nutritional, antibacterial, and organoleptic properties. Formulations used varying levels of

Mentha arvensis (1%, 2%, 3%) combined with whey (80–83 ml) and constant amounts of pineapple pulp (12 g) and sugar (5 g).

2.6 Role of different ingredients in whey lolly and fruit flavoured whey beverages

Whey-based beverages and whey lollies are functional dairy products in which each ingredient contributes specific nutritional, physicochemical, sensory, and technological functions. The scientific roles of the major ingredients are described below.

2.6.1 Whey

Whey is the liquid by-product obtained during cheese or casein manufacture. It contains lactose, whey proteins (β-lactoglobulin, α-lactalbumin), minerals, vitamins, and bioactive peptides. Whey proteins have excellent nutritional quality because they contain all essential amino acids and possess high digestibility. Whey also contributes water-binding, foaming, emulsifying, and gel-forming properties that improve beverage stability and texture. In fruit-flavoured whey beverages, whey serves as the primary dairy matrix carrying flavors and nutrients (Rejdlová, A., et al., 2025).

Functions:

- Provides high biological value proteins.
- Improves mouthfeel through protein-water interactions.
- Supplies lactose, which contributes mild sweetness and total soluble solids.
- Enhances nutritional value through minerals such as calcium, phosphorus, and potassium

2.6.2 Pineapple Juice

Pineapple juice contributes natural sugars, organic acids (primarily citric and malic acids), vitamin C, phenolic compounds, and characteristic tropical flavor.

Fruit juices are commonly incorporated into whey beverages because their acidity and flavor improve consumer acceptance while increasing nutritional value. The fruit acids also help create a refreshing taste profile (Jeličić, I., et al., 2009)

Functions:

- Improves sensory acceptability by masking the characteristic whey flavor.
- Provides natural acidity that enhances freshness.
- Supplies antioxidants and vitamin C.
- Contributes natural yellow color and aroma compounds.
- Increases total soluble solids (°Brix).

2.6.3 Sucrose

Sucrose is the most common sweetening agent used in whey beverages and frozen whey products. Sugar molecules interfere with water crystallization, reducing ice crystal size and improving smoothness in frozen products. Sweetness also suppresses excessive sourness from whey and fruit acids (Jeličić, I., et al., 2009).

Functions in whey lollies:

- Provides sweetness.
- Lowers freezing point, resulting in a softer texture.
- Reduces formation of large ice crystals.
- Improves palatability.

Functions in beverages:

- Balances acidity from whey and fruit juice.
- Enhances flavor perception.
- Increases total solids and body.

2.6.4 Glucose Syrup

Glucose syrup consists mainly of glucose, maltose, and higher saccharides obtained through starch hydrolysis. Glucose syrup contains low-molecular-weight carbohydrates that bind water and reduce mobility of free water molecules, limiting crystal formation during freezing and storage. These results in a smoother frozen product (Jeličić, I., et al., 2009)

Functions in whey lollies:

- Controls ice crystal growth.
- Improves chewiness and smooth texture.
- Reduces crystallization of sucrose.
- Enhances storage stability.

Functions in beverages:

- Increases viscosity and mouth feel.
- Provides additional sweetness with lower sweetness intensity than sucrose.
- Improves flavor release.

2.6.5 Stabilizers and Emulsifiers

Common stabilizers include pectin, carboxymethyl cellulose (CMC), guar gum, xanthan gum, and carrageenan. Emulsifiers may include mono- and diglycerides or polysorbates. Whey proteins can aggregate near their isoelectric point under acidic conditions. Stabilizers increase continuous-phase viscosity and create steric stabilization, reducing particle aggregation and sedimentation. Emulsifiers lower interfacial tension between phases, producing stable emulsions (Rejdlová, A., et al., 2025).

Stabilizers

Functions:

- Increase viscosity.
- Prevent sedimentation of proteins and fruit particles.
- Reduce phase separation.
- Improve texture and consistency.
- Control ice crystal growth in frozen products.

Emulsifiers

Functions:

- Improve dispersion of fat and flavor compounds.
- Enhance emulsion stability.
- Improve smoothness and mouth feel.
- Reduce coalescence of dispersed particles.

2.6.6 Citric Acid

Citric acid is widely used as an acidulant in fruit-based dairy beverages. Acidification increases the sensory impact of fruit flavors and inhibits microbial growth. However, excessive acidification may destabilize whey proteins; therefore, pH must be carefully controlled to avoid precipitation and sedimentation (Rejdlová, A., et al., 2025).

Functions:

- Adjusts pH to the desired level.
- Enhances fruit flavor perception.
- Provides refreshing tartness.
- Acts as a chelating agent by binding metal ions.
- Helps preserve color and flavor stability.

2.6.7 Colour

Food colors may be natural (β-carotene, turmeric, annatto) or permitted synthetic colors depending on regulations. Color strongly influences flavor perception and purchase intent. Consumers associate yellow shades with pineapple-flavored products; therefore, color standardization helps maintain sensory expectations and product consistency (Hutchings, 1999).

Functions:

- Improves visual appeal.
- Provides product identity consistent with fruit flavor.
- Compensates for color loss during processing and storage.
- Increases consumer acceptance.

2.7 Environment and Whey management

Whey disposal remains a major environmental challenge due to its high organic load. When discharged untreated, whey causes oxygen depletion in receiving water bodies, eutrophication, increased wastewater treatment costs, and environmental compliance challenges (Prazeres et al., 2012; Carvalho et al., 2013).

Table 5 : Environmental Indicators of untreated whey discharge

Parameter	Approximate Range
Biological Oxygen Demand (BOD)	30–50 g/L
Chemical Oxygen Demand (COD)	60–80 g/L
Total Solids	60–70 g/L
Lactose Content	45–50 g/L

Source: (Smithers, 2008; Ryan & Walsh, 2016; Carvalho et al., 2013).

Converting whey into functional beverages and frozen products aligns with circular bio economy principles and supports sustainable dairy development. Utilization of whey in food product innovation has become an important strategy for reducing environmental burden while improving dairy industry profitability (Smithers, 2008; Ryan & Walsh, 2016; Carvalho et al., 2013).

CHAPTER III: MATERIALS AND METHODS

3.1 Study team selection

A study team (Annex 1) was selected for study implementation. Team members organized frequent meetings to develop and coordinate the study implementation plan, including questionnaire preparation, whey sample collection, physicochemical analysis, whey product preparation, sensory analysis, and final interpretation of results.

3.2 Questionnaire preparation

Structured questionnaires (Annex 2) was prepared to capture information on dairy industries producing cheese, paneer, and chhurpi. The questionnaire collected data on milk collection volumes, per-litre milk purchase rates, and annual milk collection in litres, total production of cheese/paneer/chhurpi in kg, whey utilization practices, physical properties of whey, and the method of coagulation used.

3.3 Questionnaire fill-up and whey sample collection

A total of 11 districts were selected for whey sample collection, representing areas with high volumes of cheese, chhurpi, and paneer production. Questionnaires were completed through personal interviews with dairy, cheese factory, or farm owners. Total of 55 whey samples (yak cheese 7, kanchan cheese 7, mozarrella cheese 8, chhurpi 17 and paneer 16) from 47 dairy farms/ industries (Annex 3) were collected in labeled plastic sample bottles at factory sites and transported in ice boxes maintained below 10°C.

Table 6: Total number of whey samples collected by district and whey types

S.N.	District	Yak Cheese	Kanchan Cheese	Mozzarella Cheese	Chhurpi	Paneer	Total
1	Ilam	0	7	0	2	1	10
2	Jhapa	0	0	0	1	2	3
3	Solukhumbu	0	0	0	2	0	2
4	Dolakha	1	0	0	1	0	2
5	Ramechhap	1	0	0	2	0	3
6	Bhaktapur	0	0	0	0	2	2
7	Kavre	0	0	1	0	8	9
8	Makawanpur	0	0	1	9	3	13
9	Rasuwa	5	0	0	0	0	5
10	Nuwakot	0	0	5	0	0	5
11	Lalitpur	0	0	1	0	0	1
Total		7	7	8	17	16	55

3.4 Laboratory analysis of whey samples

Whey samples were transported to NDDB laboratory and analyzed for fat, SNF, total solid, TS, TSS, pH, acidity, reducing sugar and protein content.

3.4.1 Fat test

Fat test was carried out by Gerber method as per method.

3.4.2 SNF test

SNF test was carried out as per Quality Handbook Dairy of Development.

3.4.3 Acidity test

Acidty test was carried out as per (NBS) Nepal Beuro Standard.

3.4.4 pH test

pH test was carried out as per Laboratory Guide in Dairy Chemistry Practicals FAO.

3.4.5 Reducing sugar test

Reducing sugar test were carried out as described by Lane and Enyon Method.

3.4.6 Protein test

Protein test were carried out as per Laboratory Handbook For Dairy Industry.

3.5 Ingredients for the product development

3.5.1 Raw milk

The most preferably used raw milk for paneer preparation is buffalo milk. Buffalo milk whey was used to prepare lolly while mixed milk whey was used for beverage preparation due to unavailability of buffalo milk.

3.5.2 Coagulants

Citric acid was used as coagulant.

3.5.3 Paneer whey

The paneer whey after complete coagulation of casein mass was filtered through muslin cloth and the filtrate was taken for preparation of whey lolly and pineapple flavored whey drink.

3.5.4 Pineapple juice

The fully ripen pineapples were purchased from local market, crushed and juice was extracted, filtered, boiled, cooled and stored in refrigerator until used.

3.5.5 Sugar

The sugar was purchased from the local market.

3.5.6 Emulsifier and Stabilizer

Guar gum9 (INS 412), Carrageenan (INS407), and Xanthan Gum(INS415) were used as stabilizers and Glecerol Monostearate (INS 471) was used as emulsifier. All belonged to the Brand Maxipan XLH22147.

3.5.7 Colour and flavor

Pineapple number 1 of BUSH trade Mark of IFF (International Flavours & Fragrance India Private Limited) for flavor and color (22% dye content) of lemon yellow of Bush brand were used for flavor and color that match for whey based pineapple beverage.

3.5.8 Glucose syrup

42 DE glucose syrup was purchased from market.

3.6 Methodology

3.6.1 Paneer whey preparation

Whole milk was pasteurized at 90°c for 5 seconds and coagulated at 80°C by citric acid solution. 0.2% Citric acid on the basis of milk volume was used for coagulation. Required amount of citric acid was measured, 2% citric acid solution was made in drinking water, heated to 80°C and mixed gently to the heated milk till complete coagulation occurred. After coagulation, chhena was collected in muslin cloth and filtered whey was collected for product preparation. Whey making process is given in figure 1.

Whole milk (20 L)

Filtering

Physicochemical Analysis

Heating to 90°C

Cooling to 80°C and coagulating with 2% citric acid (0.2% of milk volume)
(40g citric acid was weighed and solubilized to 2 L of water, heated to 80°C and mixed gently with pasteurized milk at 80°C)

Filtering

Whey | Chhena

Physicochemical analysis

Use for product preparation

Figure 1: Process flow chart for paneer whey production

3.6.2 Whey lolly preparation

Whey lolly was prepared by using paneer whey, sugar, glucose syrup, pineapple flavor, stabilizer and emulsifier, color and citric acid as shown in figure 2.

Fresh Paneer whey

↓

Heating to 45°C

↓

Mixing with $2/3^{rd}$ weight of sugar, glucose syrup, colour and citric acid

↓

Heating the ingredients to 65°C . Mixing remaining $1/3^{rd}$ part of sugar with stabilizer/ emulsifier and adding to the mix

↓

Pasteurizing the whole mix at 85°C with holding time of 30 minutes

↓

Filling in Kulfi mold and allow indirect cooling to room temperature

↓

Freezing the mix at -20°C for 24 hours

↓

Removing from mold and packaging

↓

Storage at -20°C

Figure 2: Process flow chart for whey lolly preparation

3.6.2 Formulation of whey lolly

3.6.2.1 Formulation of whey lolly with sugar variation

Three formulations of whey-based beverage were prepared by varying the level of sugar while keeping the quantities of whey, stabilizer and emulsifier, citric acid, colour, and flavour constant. The objective was to evaluate the effect of different sugar concentrations on the quality characteristics of the lollies.

A total of 500 g of whey was used in each treatment as the base ingredient. Stabilizer and emulsifier were added at a rate of 2.5 g, citric acid at 1.5 g, colour at 0.25 g, and flavour at 2.25 g in all treatments. The only variable factor was the sugar content, which was adjusted to 100 **g**, 90 g, and 80 g for formulations T1, T2, and T3, respectively (Table 7).

Table 7: Formulation of whey lolly with sugar variation

Formulation	whey	sugar (g)	Stabilizer and emulsifier(g)	citric acid (gm)	Colour (gm)	Flavour (gm)
T1	500	100	2.5	1.5	0.25	2.25
T2	500	90	2.5	1.5	0.25	2.25
T3	500	80	2.5	1.5	0.25	2.25

3.6.2.2 Preparation of whey lolly with sugar variation

Different formulations (Table 7) of whey lolly at different level of sugar were prepared as shown in figure 2.

3.6.2.3 Sensory analysis of whey lolly with sugar variation

Different treatments (Table 7) of whey lolly were subjected to sensory analysis and the formulation T2 (18% sugar) was selected based on acceptance for sugar content.

3.6.2.4 Formulation of whey lolly with sugar and glucose syrup variation

The present study was conducted to evaluate the effect of partial replacement of sucrose with glucose syrup on the quality characteristics of a whey lolly (Formulation T2). Four different formulations were prepared by varying the proportions of sugar and glucose syrup while maintaining constant levels of whey, stabilizer and emulsifier, citric acid, colour, and flavour. The total amount of sweetening agent was kept constant across all formulations, with glucose syrup progressively replacing a portion of the sucrose.

Formulation G1 served as the control and contained 90 g of sugar without any glucose syrup. In formulations G2, G3, and G4, sugar was gradually replaced by glucose syrup at increasing levels. Formulations G2 contained 85.5 g sugar and 10.71 g glucose syrup, Formulations G3 contained 81 g sugar and 21.42 g glucose syrup, and Formulations G4 contained 76.5 g sugar and 32.14 g glucose syrup.

Table 8: Formulation of whey lolly with sugar and glucose syrup variation

Formulation	whey	sugar (g)	Glucose syrup(g)	Stabilizer and emulsifier(g)	citric acid (g)	Colour (g)	Flavour (g)
G1	500	90	0	2.5	1.5	0.25	2.25
G2	500	85.5	10.71	2.5	1.5	0.25	2.25
G3	500	81	21.42	2.5	1.5	0.25	2.25
G4	500	76.5	32.14	2.5	1.5	0.25	2.25

3.6.2.5 Preparation of whey lolly with sugar and glucose syrup variation

Different formulations (Table 8) of whey lolly at different levels of sugar and glucose syrup were prepared as shown in figure 2.

3.6.2.6 Sensory analysis of whey lolly with sugar and glucose syrup variation

Different formulations (Table 8) were subjected to sensory analysis and the formulations G3 (81g sugar and 21.42 g glucose syrup) was selected as final product for sugar and glucose syrup variation.

3.6.3 Pineapple flavored whey beverage preparation

Pineapple flavored whey beverage was prepared by using paneer whey, pineapple juice, sugar, stabilizer and colour.

Fresh Paneer whey

↓

Heating to 45°C

↓

Addition of sugar, pineapple juice, stabilizer and emulsifier, and colour to the whey solubilize all the ingredients at 60 °C

↓

Filling in pet bottles, sealing with aluminium foil and cap

↓

In bottle pasteurization at 85°C with holding time of 30 minutes

↓

Cooling and storage

Figure 3: Process flow chart for pineapple flavoured whey beverage

3.6.3.1 Formulation pineapple flavored whey beverage

The present trail was carried out to develop a pineapple-flavoured whey beverage and to study the effect of varying levels of pineapple juice incorporation on its quality characteristics. Four different formulations were prepared by altering the proportion of whey and pineapple juice while keeping the contents of sugar, stabilizer and emulsifier, and colour constant. The formulations (Table 9) were designed to determine the optimum level of pineapple juice that would provide desirable sensory and physicochemical properties to the beverage.

Whey was used as the principal dairy ingredient and was incorporated at different levels ranging from 350 g to 500 g. Pineapple juice was added at levels ranging from 0 g to 150 g, replacing a corresponding amount of whey in each recipe. Sugar was maintained at 50 g in all treatments to provide uniform sweetness. Stabilizer and emulsifier were added at

0.75 g to improve consistency and prevent phase separation during storage. Food-grade colour was incorporated at a level of 0.1 g in all treatments to enhance the visual appearance of the beverage (Table 9).

Table 9: Formulation of pineapple flavoured whey beverage

Formulation	whey (g)	Pinapple Juice(g)	sugar (g)	Stabilizer and emulsifier(g)	Colour (g)
F1	350	150	50	0.75	0.1
F2	400	100	50	0.75	0.1
F3	450	50	50	0.75	0.1
F4	500	0	50	0.75	0.1

3.6.3.2 Sensory analysis of pineapple flavored whey beverage

The formulations (Table 9) were subjected to sensory evaluation and F3 was selected as final product as per the highest sensory score.

3.7 Chemical and microbiological analysis of whey lolly and beverage

Chemical and microbiological analysis for both products was carried out in NDDB laboratory and in accredited labs DFTQC & Zest Lab. Chemical tests were carried out for fat, TSS, total solid, acidity, pH, reducing sugar and protein content whereas total bacterial count, yeast and mold count and coliform test were carried out for microbiological tests.

3.8 Shelf life study of pineapple flavored whey beverage

Shelf life study of pineapple flavored whey beverage was carried out in terms of smell, taste, colour, total plate count, coliform and yeast/ mold count in NDDB lab. Sealed beverage bottles were stored in room temperature and in refrigerator at 8-10°C. Microbiological tests were carried out in regular intervals (Day 1, Day 30, Day Day 60 and Day 75).

3.9 Cost calculation of whey lolly and beverage

Cost of whey lolly and pineapple flavoured whey beverage were calculated as per market price.

3.10 Statistical analysis of data

The data regarding the chemical test results of whey were analyzed using Excel 2024 and the sensory score of products were analyzed using SPSS version 21. Data were analyzed using descriptive statistical tools like mean and standard deviation while one-way ANOVA was used as an inferential tool.

CHAPTER IV: RESULTS AND DISCUSSION

4.1 Overview

This chapter presents findings from annual whey production, physicochemical analyses of whey samples collected across 11 districts, followed by results from lolly formulation optimization, beverage formulation optimization, and chemical characterization of the final products.

4.2 Whey production in Nepal

The data presented in Table 10 shows the quantity of milk utilized for paneer, chhurpi, and cheese production and the corresponding volume of whey generated by major dairy and cheese industry associations in Nepal in fiscal year 2081/82. A total of 83,286 MT were processed, resulting in the generation of approximately 75452 MT of whey, indicating that whey constitutes a major by-product of dairy processing.

Table 10: Whey Production in Nepal

S.N	Organization	Milk use for paneer/ chhurpi/cheese production (MT)	Whey collection (MT)
1	Chhurpi Industries	39645	36473
2	NDA	32737	29554
3	DIA	7760	6605
4	DDC	1597	1411
5	Himalayan Cheese Industry Association	1547	1409
Total		**83286**	**75452**

Source field survey 2026

The results indicate that Chhurpi Industries accounted for the largest share of milk, accounting to approximately 43.9% of total milk processed and 48.3% of total whey produced. The large volume of whey generated by this sector reflects the extensive production of traditional Himalayan dairy products, particularly chhurpi, which requires substantial milk inputs and results in considerable whey separation during coagulation and curd processing (Table 10).

The National Dairy Association (NDA) was the second-largest contributor, utilizing 39.3% of milk and generating 39.2% of whey. Together, Chhurpi Industries and NDA accounted for more than 85% of total whey production. This finding suggests that large-scale cheese and dairy processing facilities are the primary sources of whey generation in Nepal and therefore represent important targets for whey collection, utilization, and value-addition programs (Table 10).

The Contribution of the Dairy Industry Association (DIA) was lower (less than 10.0%) than that of Chhurpi Industries and NDA, the volume of whey produced remains substantial and highlights the importance of organized whey management practices among medium-scale dairy enterprises (Table 10).

The contributions of DDC and the Himalayan Cheese Industry Association were comparatively lower, accounting for less than 2.0% of milk use and whey generation. Despite their smaller production volumes, these industries still generate significant quantities of whey that could serve as valuable raw materials for the production of whey beverages, whey protein concentrates, fermented products, animal feed supplements, and bioactive ingredients (Table 10).

The overall results demonstrate that whey generation ranged from approximately 85% to 92% of the milk processed, which is consistent with the well-established principle that cheese and paneer manufacture typically converts only 10–20% of milk constituents into curd, while the majority of the milk volume remains in the whey fraction (Fox et al., 2017). During coagulation, casein and a portion of milk fat are retained in the curd, whereas most water, lactose, whey proteins, minerals, and soluble vitamins are transferred into whey (Smithers, 2008). Consequently, large volumes of whey are produced regardless of the cheese variety manufactured.

The high whey recovery observed in the present study indicates considerable potential for whey valorization in Nepal. Traditionally, whey has often been treated as a low-value by-product or disposed of as waste. However, whey contains approximately 50% of the nutrients originally present in milk, including lactose, whey proteins, minerals, and water-soluble vitamins (Prazeres et al., 2012). Therefore, the large annual volume of whey generated by the dairy sector represents a significant opportunity for the development of value-added products such as whey beverages, fermented drinks, whey powder, whey protein concentrates, lactose products, and functional foods.

4.2.1 Physical properties of whey samples

4.2.1.1 Colour

Most of the whey from paneer and chhurpi had greenish yellow colour whereas the whey from cheese appeared white. This may be due to the complete curdling of milk by coagulant at high temperature during paneer and chhurpi production. However, incomplete coagulation of milk during cheese manufacturing at lower temperature may result higher loss of solid in cheese whey causing white colour.

4.2.1.2 Smell and taste

Cheese whey relatively had sweet smell and taste however paneer and chhurpi whey had sour smell and taste may be due to use of citric acid, acetic acid and previous day whey as coagulant.

4.2.1.3 Chemical composition of whey samples

The chemical composition of whey samples are given in Table 11.

Table 11: Chemical composition of whey samples

Whey type	Chemical Parameters of whey							
	Fat(%)	SNF(%)	TS(%)	Acidity(%)	pH	TSS(%)	Reducing Sugar(%)	Protein (%)
Mozzarella cheese	0.98	6.21	7.19	0.17	5.75	5.25	3.16	1.13
Yak cheese	0.46	7.47	7.93	0.19	5.5	5.94	3.95	1.11
Kanchan cheese	0.39	5.77	6.1	0.17	5.74	5	2.77	0.71
Paneer	0.3	6.07	6.4	0.27	4.98	5.13	2.84	0.62
Chhurpi	0.08	6.27	6.34	0.23	5.16	5	2.8	0.51

4.2.2.1 Fat content of whey samples

The fat content of whey is influenced by several factors, including the type of milk used, coagulation method, curd handling, cutting intensity, whey drainage efficiency, and cheese-making technology. Fat losses into whey primarily occur through the escape of small milk fat globules and fat entrapped within fine curd particles during whey separation (Walstra et al., 2006).

The average fat content values ranged from 0.08% to 0.98%**,** with mozzarella cheese whey exhibiting the highest concentration of fat and chhurpi whey showing the lowest value (Table 11). The observed differences in whey fat content are primarily attributable to variations in milk composition and processing conditions. Mozzarella whey exhibited the highest fat content (0.98%), likely due to greater fat losses during curd stretching and handling, whereas chhurpi whey contained the lowest fat content (0.08%) owing to efficient fat entrapment within the compact acid-coagulated curd matrix (Fox et al., 2017; Tamang et al., 2020). The relatively higher fat content of yak cheese whey (0.46%) may be associated with the naturally high fat concentration of yak milk (Li et al., 2011). These findings indicate that cheese-making technology significantly influences fat partitioning between curd and whey.

4.2.2.2 SNF content of whey samples

The SNF content of whey represents the concentration of lactose, whey proteins, minerals, organic acids, and other water-soluble milk constituents**,** excluding fat. Variations in SNF among whey types are mainly attributed to differences in milk composition, coagulation mechanism (acid or rennet), heating intensity, curd handling, and whey drainage efficiency (Walstra et al., 2006; Fox et al., 2017).

The highest SNF content was found in yak cheese whey(7.47%) and the lowest in kanchan cheese whey (5.77%) (Table 11). The significantly higher SNF content observed in yak cheese whey can be attributed to the naturally high total solids, protein, lactose, and mineral content of yak milk, whereas the lower SNF content in kanchan cheese whey may reflect more efficient retention of milk solids within the curd. Difference in coagulation mechanism, heat treatment, and whey separation efficiency further influence the partitioning of soluble proteins, lactose, and minerals into whey, resulting in the observed variation among whey types (Li et al., 2011; Fox et al., 2017).

4.2.2.3 Acidity of whey samples

Titrable acidity is an important quality parameter of whey and reflects the presence of lactic acid, soluble phosphate salts, citrate, proteins, and other acidic constituents. The acidity of whey is influenced by milk composition, starter culture activity, extent of lactose fermentation, coagulation method (acid or rennet), heat treatment, and processing conditions during cheese manufacture (Walstra et al., 2006).

The significantly higher acidity observed in paneer whey (0.27%) and chhurpi whey (0.23%) may be attributed to acid coagulation and lactic acid fermentation during manufacture, which increase the concentration of organic acids and soluble minerals in the whey (Table 11). Conversely, the lower acidity of Mozzarella and Kanchan cheese whey (0.17%) reflect the predominance of rennet coagulation, where limited acid development occurs before whey separation (Fox et al., 2017; Sachdeva & Singh, 1988).

4.2.2.4 Total solid (TS) content of whey samples

The Total Solid (TS) content of the whey samples ranged from 6.10% to 7.93%, with yak cheese whey exhibiting the highest value (7.93%) and the lowest value in kanchan cheeses whey (6.10%) (Table 11). The elevated TSS in yak cheese whey may be attributed to the naturally higher total solids, lactose, protein, and mineral content of yak milk, which increases the concentration of soluble constituents retained in whey (Li et al., 2011). Similarly, the relatively high TSS of Mozzarella whey (7.19%) reflects the retention of lactose, whey proteins, and soluble minerals following rennet coagulation (Fox et al., 2017). Lower TSS values observed in paneer, chhurpi, and Kanchan cheese whey may result from protein denaturation during acid coagulation, lactose utilization during fermentation, and greater retention of milk solids within the curd matrix (Sachdeva & Singh, 1988; Tamang et al., 2020). These findings demonstrate that milk composition and cheese-making technology significantly influence the concentration of total solids in whey.

4.2.2.5 pH of whey samples

The pH of whey is an important indicator of its chemical composition, microbial activity, and processing conditions. Whey pH is primarily influenced by the coagulation method, extent of lactose fermentation, lactic acid production, mineral equilibrium, and buffering capacity of milk proteins. Generally, whey derived from acid-coagulated products exhibits lower pH values, whereas whey obtained from rennet-coagulated cheeses tends to have higher pH values because less acid is generated during coagulation (Fox et al., 2017; Walstra et al., 2006).

The pH of whey samples ranged from 4.98 to 5.75, with paneer whey exhibiting the lowest pH and Mozzarella whey the highest (Table 11). The lower pH of paneer whey may be attributed to direct acid coagulation during manufacture, which results in greater retention of acidic compounds in the whey fraction (Sachdeva & Singh, 1988). Similarly, the relatively low pH of chhurpi whey reflects lactic acid production during fermentation (Tamang et al., 2020). In contrast, the higher pH values observed in Mozzarella and Kanchan cheese whey is the characteristics of rennet-coagulated cheeses, where limited acid development occurs before whey separation (Fox et al., 2017). The intermediate pH of yak cheese whey may be associated with the higher buffering capacity of yak milk resulting from its elevated protein and mineral content (Li et al., 2011). These findings demonstrate that coagulation method and fermentation intensity are the principal factors influencing whey pH.

4.2.2.6 Total soluble solid (TSS) content of whey samples

Total soluble solids (TSS) represent the concentration of dissolved constituents in whey, including lactose, whey proteins, soluble minerals, organic acids, peptides, and other water-soluble compounds. Among these components, lactose is the major contributor, accounting for approximately 70–75% of total whey solids. Therefore, variations in TSS largely reflect differences in milk composition, cheese-making technology, coagulation method, fermentation intensity, and the partitioning of soluble milk constituents between curd and whey (Smithers, 2008; Walstra et al., 2006).

The total soluble solids content of the whey samples ranged from 5.00% to 5.94%, with yak cheese whey exhibiting the highest value and Kanchan cheese and chhurpi whey the lowest (Table 11). The elevated TSS observed in yak cheese whey may be attributed to the naturally higher concentrations of lactose, protein, and minerals in yak milk, resulting in greater retention of soluble nutrients in the whey fraction (Li et al., 2011). The relatively high TSS of Mozzarella whey is characteristic of rennet-coagulated cheeses, where most soluble constituents remain in whey following curd formation (Fox et al., 2017). Lower TSS values observed in paneer and chhurpi whey may result from protein denaturation during acid coagulation and partial lactose utilization during fermentation, respectively (Sachdeva & Singh, 1988; Tamang et al., 2020). Furthermore, the total soluble solid content are proportional to the total solid content of the respective whey samples. These findings indicate that both milk composition and processing technology significantly influence the concentration of soluble solids in whey.

4.2.2.7 Reducing sugar (RS) content of whey samples

Reducing sugars in whey are composed predominantly of lactose**,** the principal carbohydrate of milk, along with small quantities of glucose and galactose that may arise from lactose hydrolysis during fermentation or processing. Since lactose is highly water-soluble and remains largely in the whey fraction during cheese manufacture, the reducing sugar content of whey serves as an indicator of the extent of lactose retention and utilization during processing. Variations in reducing sugar content are influenced by milk composition, coagulation method, microbial fermentation, heat treatment, and whey separation efficiency (Fox et al., 2017; Smithers, 2008).

The reducing sugar content of whey samples ranged from 2.77% to 3.95%, with yak cheese whey exhibiting the highest value and Kanchan cheese whey the lowest (Table 11). The elevated reducing sugar content in yak cheese whey may be attributed to the higher lactose concentration naturally present in yak milk and thus seeping of lactose in the whey fraction during cheese manufacture (Li et al., 2011). Similarly, Mozzarella whey contained relatively high levels of reducing sugars because rennet coagulation retains most lactose in whey while minimizing carbohydrate losses to the curd (Fox et al., 2017). In contrast, the lower reducing sugar contents observed in chhurpi and Kanchan cheese whey may be associated with lactose utilization by lactic acid bacteria during fermentation and subsequent conversion into lactic acid (Tamang et al., 2020). These findings demonstrate that milk composition, fermentation intensity, and cheese-making technology are the major factors governing the reducing sugar content of whey.

4.2.2.8 Protein content of whey samples

Protein is one of the most valuable nutritional components of whey and consists primarily of β-lactoglobulin, α-lactalbumin, bovine serum albumin, immunoglobulins, proteose-peptones, and minor bioactive proteins**.** The protein content of whey is influenced by milk composition, coagulation method, heat treatment, pH during coagulation, whey drainage efficiency, and the extent of whey protein denaturation during processing (Smithers, 2008; Walstra et al., 2006).

The protein content of the whey samples ranged from 0.51% to 1.13%, with Mozzarella whey (1.13%) and yak cheese whey (1.11%) exhibiting significantly higher values than the other whey types (Table 11). The elevated protein content in Mozzarella whey is characteristics of rennet-coagulated cheeses, where most whey proteins remain in the liquid phase after casein coagulation (Fox et al., 2017). Similarly, the high protein content of yak cheese whey may be attributed to the naturally greater protein concentration of yak milk (Li et al., 2011). In contrast, the lower protein contents observed in paneer and chhurpi whey may result from heat-induced denaturation of whey proteins and their subsequent incorporation into the coagulated curd during acid coagulation (Sachdeva & Singh, 1988; Tamang et al., 2020). These findings indicate that both milk composition and processing conditions strongly influence protein recovery in whey

4.3 Selection of coagulant

Fresh whey was prepared in NDDB lab using citric acid and acetic acid as coagulants. Trials were carried out for acceptability of coagulants. Acetic acid whey could not be used for whey lolly and whey beverage preparation as it imparted pungent smell in acetic acid smell to the products. Citric acid was selected as coagulant for whey preparation due to its clean taste in whey lolly and beverages.

4.4 Chemical composition of milk and whey for lolly preparation

The physicochemical composition of milk and paneer whey differed considerably due to the partitioning of milk constituents during paneer manufacture. Paneer is produced by acid coagulation of heated milk, during which casein proteins and most of the fat are retained in the curd, while water-soluble components such as lactose, whey proteins, minerals, and organic acids are transferred to the whey fraction. Consequently, significant changes occur in acidity, pH, fat, protein, solids-not-fat (SNF), total soluble solids (TSS), and reducing sugar content between milk and whey (Walstra et al., 2006; Fox et al., 2017).

Table 12: Chemical composition of milk and whey for lolly preparation

Chemical Parameters	Milk (%)	Paneer whey (%)
Acidity(as lactic acid)	0.12	0.25
Fat	5.09	0.71
SNF	8.79	5.54
Protein	3.38	0.43
pH	6.72	5.2
TSS	11	5
Reducing Sugar	3.1	3.34

(NDDB, 2026)

Table 12 shows the chemical composition of milk and paneer whey used for whey lolly preparation. The conversion of milk into paneer resulted in significant changes in physicochemical composition. Acidity increased from 0.12% to 0.25%, while pH decreased from 6.72 to 5.20 due to acid-induced coagulation. Fat and protein contents decreased substantially from 5.09% to 0.71% and from 3.38% to 0.43%, respectively, reflecting the retention of fat globules and casein proteins within the paneer curd. Similarly, SNF and TSS declined from 8.79% to 5.54% and from 11.0% to 5.0%, respectively, owing to the removal of major milk solids during coagulation. In contrast, reducing sugar content increased slightly from 3.10% to 3.34% because lactose remained largely in the whey fraction. These observations are consistent with the known partitioning behavior of milk constituents during paneer manufacture and highlight the nutritional potential of paneer whey as a source of lactose, whey proteins, and minerals (Fox et al., 2017; Smithers, 2008).

4.5. Optimization of sugar concentration for whey lolly

The three formulations (Table 7) of whey lolly were prepared and the formulations were subjected to sensory analysis using 9 point hedonic rating scale (Annex 4) in terms of sweetness, mouth feel, flavor and aroma to select the best alternative.

4.5.1 Effect of sugar variation on sweetness score of lolly

Sweetness is one of the most important sensory attributes affecting consumer acceptance of food products because it contributes directly to palatability and overall liking. The perception of sweetness is influenced by the concentration and type of sugars present, interactions with other taste compounds, and the food matrix. Increased levels of soluble sugars generally result in higher sweetness intensity and improved consumer preference, provided the sweetness remains balanced with other sensory attributes.

The descriptive statistics indicate clear differences in the sweetness scores among the three sugar variation formulations. Formulation T2 recorded the highest mean sweetness score (7.53 ± 0.52), suggesting that it was perceived as the sweetest and most preferred formulation by the panelists. Formulation T1 achieved a mean score (6.87 ± 0.35), while T3 had the lowest mean sweetness score (5.53 ± 0.52), indicating comparatively lower sweetness acceptability (Annex 5).

The one-way ANOVA showed that sugar variation had a significant difference on the sweetness score of the lolly samples ($F = 71.014$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, indicating significant differences in mean sweetness scores among the treatments. Since, formulation T2 recorded the highest mean sweetness score compared to other formulations. Therefore, T2 was the preferred formulation in terms of sweetness and can be considered the optimum sugar concentration for the lolly samples (Annex 5).

Similar observations have been reported by Lawless and Heymann (2010) and Stone and Sidel (2004), who identified sweetness as a critical attribute influencing consumer acceptance of food products.

4.5.2 Effect of sugar variation on mouth feel score of lolly

Mouth feel is an important sensory attribute that influences consumer perception and acceptance of confectionery products. It encompasses the tactile sensations experienced in the mouth during consumption, including smoothness, viscosity, texture, cohesiveness, and the rate of dissolution. In confectionery products such as lollies, sugar concentration plays a crucial role in determining mouth feel by affecting the physical structure, crystal formation, moisture retention, and dissolution characteristics of the product (Lawless & Heymann, 2010).

The descriptive statistics indicate clear differences in the mouth feel scores among the three sugar variation formulations. Formulation T2 recorded the highest mean mouth feel score (8.00 ± 0.38), suggesting that it was perceived as having the most desirable mouth feel by the panelists. Formulation T1 achieved a mean score of 6.87 ± 0.74, while T3 had the lowest mean mouth feel score (4.33 ± 0.98), indicating comparatively lower acceptability in terms of mouth feel (Annex 6).

The one-way ANOVA showed that sugar variation had a significant difference on the mouth feel score of the lolly samples ($F = 96.26$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, indicating significant differences in mean mouth feel scores among the formulations. As formulation T2 recorded the highest mean mouth feel score, it was the preferred formulation in terms of mouth feel and can be considered the optimum concentration for the lolly samples (Annex 6).

Similar observations have been reported by Lawless and Heymann (2010) and Stone and Sidel (2004), who emphasized that texture and mouth feel are major determinants of consumer acceptance and overall product preference. Therefore, the findings indicate that optimizing sugar concentration is essential for achieving desirable mouth feel characteristics and maximizing consumer acceptability of lolly products.

4.5.3 Effect of Sugar variation on flavor score of lolly

Flavour is a critical sensory attribute that strongly influences consumer acceptance of confectionery products. It is a complex sensation resulting from the integration of taste, aroma, and oral sensory perceptions. Sugar not only contributes sweetness but also enhances flavour perception by modifying the release of volatile compounds, masking undesirable tastes, and improving the overall flavour balance of food products (Lawless & Heymann, 2010)

The descriptive statistics showed noticeable variation in the flavor scores among the three sugar formulations. Formulation T2 obtained the highest mean flavor score (7.53 ± 0.52), indicating that it was the most preferred formulation in terms of flavor. In comparison, T1 received a moderate mean score (5.27 ± 0.59), whereas T3 recorded the lowest mean flavor score (4.53 ± 0.52), suggesting lower flavor acceptability among the panelists (Annex 7).

The one-way ANOVA indicated that sugar variation had a statistically significant effect on the flavor score of the lolly samples ($F = 124.269$, $p < 0.001$). Since the p-value was less than 0.05, the null hypothesis was rejected, confirming significant differences in flavor scores among the formulations. As formulation T2 achieved the highest mean flavor score, it was considered the most acceptable formulation with respect to flavor and can be regarded as the optimum sugar concentration for the lolly samples (Annex 7).

These findings are consistent with previous studies indicating that flavour is a major determinant of consumer acceptance and that appropriate sugar levels are essential for maximizing flavour quality in confectionery products (Lawless & Heymann, 2010; Meilgaard et al., 2016).

4.5.4 Effect of Sugar variation on aroma score of lolly

Aroma is a fundamental sensory attribute that significantly influences the overall quality and consumer acceptance of food products. Aroma perception arises from volatile compounds released from the food matrix and detected by olfactory receptors during consumption. In confectionery products, sugar not only contributes sweetness but also influences the perception and release of aroma compounds through its interactions with volatile substances, moisture content, and product structure (Belitz et al., 2009; Damodaran et al., 2017).

The descriptive statistics demonstrated noticeable differences in the aroma scores across the three sugar variation formulations. Formulation T2 achieved the highest mean aroma score (7.00 ± 0.38), indicating the greatest preference among the panelists. Formulation T1 followed closely with a mean score of 6.93 ± 0.46, whereas T3 recorded the lowest aroma score (4.27 ± 0.80), suggesting comparatively lower acceptability (Annex 8).

The one-way ANOVA revealed that sugar variation significantly influenced the aroma score of the lolly samples ($F = 110.452$, $p < 0.001$). Since the p-value was below the 0.05 level of significance, the null hypothesis was rejected, confirming significant differences in aroma scores among the formulations. Although the aroma scores of T1 and T2 were comparable, T2 recorded the highest mean score and was therefore identified as the most acceptable formulation in terms of aroma, indicating that it represents the optimum sugar concentration for the lolly samples (Annex 8).

These findings are consistent with sensory evaluation studies indicating that aroma is a key determinant of flavor perception and overall product acceptability (Lawless & Heymann, 2010; Stone & Sidel, 2004)."

4.6 Optimization of sugar and glucose syrup concentration

The four formulations (Table 8) of whey lolly were prepared and subjected to sensory analysis in terms of sweetness, flavor, mouth feel and aroma to select best alternative.

4.6.1 Effect of sugar and glucose syrup variation on sweetness score of lolly

Sweetness is one of the most influential sensory attributes in confectionery products and is a primary determinant of consumer acceptance. The perception of sweetness is affected not only by the concentration of sucrose but also by the presence of other carbohydrates, such as glucose syrup, which can modify sweetness intensity, flavor balance, and overall sensory perception. Glucose syrup contributes to sweetness while also influencing the physical structure and texture of confectionery products, thereby affecting the overall eating experience (Belitz et al., 2009; Damodaran et al., 2017).

The descriptive statistics showed clear differences in the sweetness scores among the four sugar and glucose syrup variation formulations. Formulation F3 recorded the highest mean sweetness score (8.00 ± 0.38), indicating that it was the most preferred formulation in terms of sweetness. Formulation F4 followed closely with a mean score of 7.93 ± 0.46, while F2 obtained a moderate sweetness score (6.53 ± 0.52). Formulation F1 recorded the lowest mean sweetness score (5.60 ± 0.51), suggesting comparatively lower sweetness acceptability among the panelists (Annex 9).

The one-way ANOVA revealed that the combined variation of sugar and glucose syrup had a significant effect on the sweetness score of the lolly samples ($F = 92.395$, $p < 0.001$). Since the p-value was less than 0.05, the null hypothesis was rejected, confirming significant differences in mean sweetness scores among the formulations. As formulation F3 achieved the highest mean sweetness score, it was considered the most preferred formulation in terms of sweetness and can be regarded as the optimum combination of sugar and glucose syrup for the lolly samples (Annex 9).

These findings are consistent with previous reports indicating that sweetness is a major determinant of consumer preference and that optimization of sweetener composition is essential for improving the sensory acceptability of confectionery products (Lawless & Heymann, 2010; Stone & Sidel, 2004).

4.6.2 Effect of sugar and glucose syrup variation on mouth feel score of lolly

Mouth feel is a critical sensory attribute that describes the tactile sensations perceived in the oral cavity during food consumption, including smoothness, viscosity, cohesiveness, chewiness, and dissolution characteristics. In confectionery products, mouth feel is strongly influenced by the composition and ratio of sweetening agents such as sucrose and glucose syrup. Glucose syrup is widely used in candy and lolly manufacture because it modifies texture, controls crystallization, improves moisture retention, and contributes to a smoother and more desirable mouth feel (Jackson, 2009; Belitz et al., 2009).

The descriptive statistics indicated noticeable differences in the mouth feel scores among the four sugar and glucose syrup variation formulations. Formulation G3 achieved the highest mean mouth feel score (8.00 ± 0.00), reflecting the highest level of panelist preference and complete agreement in the ratings. Formulations G4 and G2 recorded mean scores of 7.00 ± 0.76 and 6.93 ± 0.46, respectively, whereas G1 obtained the lowest mean mouth feel score (5.40 ± 0.63), indicating comparatively lower acceptability (Annex 10).

The one-way ANOVA demonstrated that the combined variation of sugar and glucose syrup had a significant effect on the mouth feel score of the lolly samples ($F = 58.484$, $p < 0.001$). Since the p-value was less than 0.05, the null hypothesis was rejected, confirming significant differences in mouth feel scores among the formulations. As formulation G3 recorded the highest mean mouth feel score, it was identified as the most acceptable formulation in terms of mouth feel and can be considered the optimum combination of sugar and glucose syrup for the lolly samples (Annex 10).

These findings are consistent with previous studies demonstrating that mouth feel is a major determinant of consumer acceptance and that optimization of sweetener composition is essential for achieving desirable textural quality in confectionery products (Lawless & Heymann, 2010; Stone & Sidel, 2004).

4.6.3 Effect of sugar and glucose syrup variation on flavour score of lolly

Flavour is one of the most important sensory attributes influencing consumer acceptance of confectionery products. It is a complex perception resulting from the interaction of taste, aroma, and trigeminal sensations. In sugar confectionery, the ratio of sucrose to glucose syrup plays a crucial role in flavour development because these ingredients affect sweetness intensity, flavour release, aroma retention, and overall sensory balance. Appropriate proportions of sugar and glucose syrup can enhance desirable flavour notes while minimizing undesirable sensory characteristics (Belitz et al., 2009; Damodaran et al., 2017).

The descriptive statistics revealed distinct differences in the flavor scores among the four sugar and glucose syrup variation formulations. Formulation G3 obtained the highest mean flavor score (7.93 ± 0.46), indicating that it was the most preferred formulation with respect to flavor. Formulations G4 followed with a mean score of 7.47 ± 0.52, while G2 achieved a moderate score (6.47 ± 0.52). In contrast, G1 recorded the lowest mean flavor score (5.33 ± 0.49), reflecting comparatively lower flavor acceptability (Annex 11).

The one-way ANOVA showed that the combined variation of sugar and glucose syrup had a significant effect on the flavor score of the lolly samples ($F = 81.372$, $p < 0.001$). As the p-value was less than 0.05, the null hypothesis was rejected, indicating significant differences in flavor scores among the treatments. Since formulation G3 achieved the highest mean flavor score, it was identified as the most preferred formulation in terms of flavor and can be considered the optimum combination of sugar and glucose syrup for the lolly samples (Annex 11).

These findings are consistent with previous studies indicating that flavour is a major determinant of consumer preference and that optimization of sweetener composition is essential for achieving desirable sensory quality in confectionery products (Lawless & Heymann, 2010; Stone & Sidel, 2004).

4.6.4 Effect of sugar and glucose syrup variation on aroma score of lolly

Aroma is a key sensory attribute that contributes significantly to flavor perception and overall consumer acceptance of confectionery products. Aroma results from the release of volatile compounds that are detected by the olfactory system during consumption. The composition of sweeteners, particularly the ratio of sucrose to glucose syrup, can influence aroma perception by affecting the retention, release, and stability of volatile flavor compounds within the confectionery matrix. Therefore, optimizing sugar and glucose syrup levels is essential for achieving desirable aroma characteristics in lolly products (Belitz et al., 2009; Damodaran et al., 2017).

The descriptive statistics demonstrated clear variation in the aroma scores among the four sugar and glucose syrup formulations. Formulation G3 attained the highest mean aroma score (7.93 ± 0.46), indicating the greatest preference for aroma among the panelists. Formulations G4 recorded the second-highest mean score (6.27 ± 0.59), followed by G2 (5.40 ± 0.51). In contrast, formulation G1 had the lowest mean aroma score (4.47 ± 0.64), suggesting comparatively lower aroma acceptability (Annex 12).

The one-way ANOVA indicated that the combined variation of sugar and glucose syrup significantly affected the aroma score of the lolly samples ($F = 106.121$, $p < 0.001$). As the p-value was below the 0.05 significance level, the null hypothesis was rejected, confirming significant differences in aroma scores among the formulations. Since formulation G3 produced the highest mean aroma score, it was considered the most acceptable formulation in terms of aroma and can be regarded as the optimum combination of sugar and glucose syrup for the lolly samples (Annex 12).

These findings are consistent with previous reports indicating that aroma is a major contributor to flavor perception and consumer preference, and that optimizing sweetener composition is essential for improving sensory acceptability in confectionery products (Lawless & Heymann, 2010; Stone & Sidel, 2004).

The final whey lolly was selected on the basis of suitable variations of sugar and glucose syrup concentrations. From the sensory analysis, formulation G3 was selected as final product.

4.7 Chemical composition of whey lolly

The final whey lolly G3 (Table 8) was analyzed for fat, Total solid, acidity, TSS, pH, protein and reducing sugar and the values are presented in Table 13 .

Table 13: Chemical composition of whey lolly

S. No.	Chemical Parameters	Observed value (%)
1	Fat	0.40
2	Total Solid	21.7
3	Acidity as citric acid	0.384
4	Total Soluble Solid	21
5	pH	4.0
6	Protein	0.32
7	Reducing Sugar	4.42

4.8 Cost of whey lolly

In making 120 kg batch of whey lolly G3 (Table 8), total of 3428 pieces of 35 g lolly was prepared and thus the lolly production cost per unit was calculated Rs 4.07 per unit(Table 14).

Table 14: Production cost of whey lolly

S. N	Particulars	cost/pcs(NRs)
1	Steam consumption	0.07
2	Cooling and storage cost	0.07
3	Packaging cost	2.00
4	Whey cost	0
5	Sugar cost	0.48
6	Glucose Syrup	1.26
7	Stabilizer and emulsifier cost	0.05
8	Colour	0.01
9	Flavour	0.13
Total cost		**4.07**

(Field Suevey, 2026)

4.9 Preparation of pineapple flavoured whey beverage

Different formulations (Table 9) of Pineapple flavoured whey beverage were prepared by method utilized in figure 3.

4.9.1 Composition of milk, whey and pineapple juice for beverage preparation

Mixed milk with 5% fat, 8.11% SNF, 0.16% acidity (as lactic acid), and 2.59% protein, pH 6.6, 9% TSS and 2.43% reducing sugar was used for paneer whey preparation. Paneer whey was prepared as shown in figure 1. After whey separation, its chemical properties of raw materials used were analyzed and the results are presented in Table 15.

Table 15 : Composition of milk, whey and pineapple juice for beverage preparation

S.N	Particulars (%)	Milk	Paneer whey	Pineapple Juice
1	Acidity	0.16	0.24	0.45
2	Fat	5.06	0.71	0
3	SNF	8.11	5.06	0
4	Protein	2.59	0.44	0.38
5	pH	6.6	5	4.02
6	TSS	9	5	11
7	Reducing Sugar	2.43	2.6	6.16

4.9.2 Optimization of whey and pineapple juice ratio

The four formulations (Table 9) of whey lolly were prepared subjected to sensory analysis using 9 point hedonic rating scale (Annex 13) in terms of sweetness, mouth feel, flavor and aroma to select the best alternative.

4.9.2.1 Effect of whey and pineapple juice ratio in sweetness score of beverage

Sweetness perception is known to be strongly affected by the interaction between sugars and organic acids, which collectively determine the palatability and consumer acceptance of fruit beverages (Stone & Sidel, 2004; Lawless & Heymann, 2010). Pineapple juice contains appreciable amounts of sucrose, glucose, and fructose that contribute significantly to sweetness and overall flavor acceptability (Belitz et al., 2009).

The descriptive statistics showed differences in the sweetness scores among the four whey and pineapple juice formulations. Formulation F3 recorded the highest mean sweetness score (7.67 ± 0.49), followed by F2 (7.27 ± 0.46) and F1 (6.80 ± 0.68). Formulation F4 had the lowest mean sweetness score (4.00 ± 0.38), indicating the least sweetness acceptability (Annex 14).

The one-way ANOVA revealed that the variation in whey and pineapple juice had a significant effect on the sweetness score of the beverage ($F = 157.903$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, confirming significant differences among the formulations. As formulation F3 achieved the highest mean sweetness score, it was considered the most preferred formulation in terms of sweetness and the optimum whey and pineapple juice combination for the beverage (Annex 14).

4.9.2.2 Effect of whey and pineapple juice ratio in mouth feel score of beverage

Whey proteins contribute to body, smoothness, and viscosity, while fruit solids enhance texture and improve the overall sensory experience. A proper balance between liquid consistency and total soluble solids is known to positively influence mouth feel perception in dairy-fruit beverages (Chandan & Kilara, 2010). Similar observations have been reported by Stone and Sidel (2004), who emphasized that mouth feel is a critical sensory attribute affecting consumer acceptance and product preference.

The descriptive statistics indicated differences in the mouth feel scores among the four whey and pineapple juice formulations. Formulation T3 recorded the highest mean mouth feel score (8.00 ± 0.38), followed by F1 (7.53 ± 0.64) and F2 (7.47 ± 0.52). Formulation F4 obtained the lowest mean mouth feel score (4.07 ± 0.46), indicating the least acceptable mouth feel (Annex 15).

The one-way ANOVA showed that the variation in whey and pineapple juice had a significant effect on the mouth feel score of the beverage ($F = 192.284$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, confirming significant differences among the formulations. As formulation F3 achieved the highest mean mouth feel score, it was considered the most preferred formulation in terms of mouth feel and the optimum whey and pineapple juice combination for the beverage (Annex 15).

The superior performance of F3 may be attributed to the optimal balance of whey proteins and fruit solids, which enhanced viscosity, smoothness, and body of the beverage. Whey proteins are known to improve texture, consistency, and sensory properties of dairy-based beverages, while fruit solids contribute to desirable mouth feel characteristics and consumer acceptability (Chandan & Kilara, 2010).

4.9.2.3 Effect of whey and pineapple juice ratio in flavour score of beverage

Flavour is one of the most important sensory attributes influencing consumer acceptance of fruit-based dairy beverages. The flavour scores of pineapple-flavoured whey beverages showed considerable variation among the treatments, indicating that different proportions of whey and pineapple juice significantly affected flavour perception.

The descriptive statistics showed variation in the flavor scores among the four whey and pineapple juice ratio formulations. Formulation F3 recorded the highest mean flavor score (8.00 ± 0.54), followed by F1 (7.80 ± 0.41) and F2 (7.33 ± 0.62). Treatment F4 had the lowest mean flavor score (4.00 ± 0.00), indicating the lowest flavor acceptability (Annex 16).

The one-way ANOVA revealed that the whey and pineapple juice ratio had a significant effect on the flavor score of the beverage ($F = 252.080$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, confirming significant differences among the treatments. As formulation F3 achieved the highest mean flavor score, it was considered the most preferred formulation in terms of flavor and the optimum whey and pineapple juice ratio for the beverage (Annex 16).

The superior flavour acceptability of F3 may be attributed to an optimal balance of pineapple aroma compounds, sweetness, acidity, and whey constituents, which enhanced overall flavour quality. These findings indicate that formulation optimization is essential for improving flavour acceptability and consumer preference in pineapple-flavoured whey beverages (Stone & Sidel, 2004; Lawless & Heymann, 2010).

4.9.2.4 Effect of whey and pineapple juice ratio in aroma score of beverage

Aroma is a critical sensory attribute that significantly influences consumer perception and acceptance of fruit-based beverages, as it contributes to the overall flavor experience before tasting. The aroma scores of pineapple-flavoured whey beverages varied significantly among treatments, indicating that the proportion of whey and pineapple juice had a marked effect on the aromatic quality of the beverage.

The descriptive statistics showed differences in the aroma scores among the four whey and pineapple juice ratio formulations. Formulation F3 recorded the highest mean aroma score (8.00 ± 0.00), followed closely by F1 (7.93 ± 0.26) and F2 (7.27 ± 0.46). Formulation F4 obtained the lowest mean aroma score (4.00 ± 0.00), indicating the lowest aroma acceptability (Annex 17).

The one-way ANOVA indicated that the whey and pineapple juice ratio had a significant effect on the aroma score of the beverage ($F = 780.782$, $p < 0.001$). Since $p < 0.05$, the null hypothesis was rejected, confirming significant differences among the treatments. As formulation F3 achieved the highest mean aroma score, it was considered the most preferred formulation in terms of aroma and the optimum whey and pineapple juice ratio for the beverage (Annex 17).

The superior aroma acceptability of F3 may be attributed to the optimal concentration of pineapple-derived volatile compounds, including esters and aldehydes, which enhanced the characteristic fruity aroma and improved sensory quality. These findings suggest that the proportion of pineapple juice plays a crucial role in determining aroma acceptability and overall consumer preference in pineapple-flavoured whey beverages (Belitz et al., 2009; Stone & Sidel, 2004; Lawless & Heymann, 2010).

The pineapple flavoured whey beverage (F3, Table 9) was selected as final product as per highest sensory score.

4.10 Chemical composition of pineapple flavored whey beverage

The final whey beverage F3 (Table 9) was analyzed for fat, Total solid, acidity, TSS, pH, protein , reducing sugar and total ash and the values are presented in Table 16.

Table 16: Chemical composition of pineapple flavoured whey beverage

Particular	Fat (%)	Total solid(%)	Acidity (%)	Total soluble solid (%)	pH	Protein (%)	Reducing sugar (%)	Total ash (%)
Pineapple flavoured whey beverage	0.40	16.00	0.20	15.60	4.20	0.30	2.69	0.08

4.11 Microbiological status of pineapple flavored whey beverage

Pineapple flavored whey beverage was subjected to microbiological analysis for total bacterial count (TBC), Coliform count and yeast/mold count. In day 1, TBC was found to be $4.5*10^1$ CFU/ml. Coliform and yeast/ mold count were absent in the product.

4.12 Shelf life of the pineapple flavored whey beverage

After the preparation of pineapple flavored whey beverage, the sealed pet bottles were stored under refrigeration and in room temperature respectively and their shelf life were tested in terms of smell, taste, colour, total plate count, coliform and yeast/ mold count. The test duration was 75 days. Physically the beverage had quite good smell and taste of pineapple in the beginning and these attributes were gradually decreasing upon time advancement.

Nepal has no specific standards for whey based beverages. However, dairy quality standards used in Nepal, pasteurized milk should have a total plate count not exceeding 3 $\times 10^4$ CFU/ml and yeast and mold count not exceeding 10 CFU/ml and Coliform count should be nil/ ml of milk.

Table 17: Microbial properties of pineapple flavoured whey beverage

No.of days	Microbiological properties					
	Under refrigeration			Room Temperature		
	TPC (CFU/ml)	Coliform (CFU/ml)	Yeast /Mold (CFU/ml)	TPC (CFU/ml)	Coliform (CFU/ml)	Yeast /Mold (CFU/ml)
1	$4.5*10^1$	0	0	$4.5*10^1$	0	0
30	$1*10^3$	0	0	$2*10^3$	0	8
60	$1*10^4$	0	8	$3*10^5$	10	$1.5*10^2$
75	$2.5*10^5$	5	10^2	-	-	-

On the above basis, the product under refrigeration was good till day 60 as it showed TPC, coliform and yeast/mold count under the specifications. At day 75, the product revealed the values TPC, coliform and yeast and mold count as $2.5*10^5$ cfu/ml, 5 cfu/ml and 10^2 cfu/ml respectively which exceeds the permitted specifications. Thus from this research, the shelf life of the pineapple flavored whey beverage under refrigeration was estimated as 60 days only (Table 17).

Similarly the shelf life the beverage stored under room temperature was estimated only 30 days because on 60 day test it showed the TPC, coliform and yeast/mold count as $3*10^5$ CFU/ml, 10CFU/ml and $1.5*10^2$CFU/ml respectively which exceeds the permitted specifications (Table 17).

4.13 Cost of pineapple flavoured whey beverage

The cost of pineapple flavoured whey beverage was calculated Rs 20.61 per 200 ml bottle.

Table 18: Production cost of pineapple flavoured whey beverage

S. N	Particulars	Cost/bottle (NRs)
1	Steam consumption	0.38
2	Cooling and storage cost	0.33
3	Packaging cost (600 bottles)	12.00
4	Whey cost	0.00
5	Sugar cost	1.75
6	Pineapple juice	5.83
7	Stabilizer and emulsifier cost	0.29
8	Colour	0.03
Total cost		**20.61**

CHAPTER V: SCALABILITY AND ECONOMIC ASPECTS OF OPERATION

- Nepal's dairy industry produces large quantities of whey, much of which is underutilized despite its high nutritional value. Converting whey into value-added products can reduce environmental pollution, increase income for dairy processors, and support sustainable dairy development.
- Whey lolly is a low-cost, easy-to-produce product requiring minimal equipment, making it suitable for dairy cooperatives and small enterprises. It has good market potential in schools, tourist areas, and local markets, although its commercial growth is limited by seasonal demand, cold-chain requirements, and relatively low profit per unit.
- Pineapple-flavoured whey beverage offers greater long-term commercial potential. Although it requires higher investment for pasteurization, bottling, and quality control, it can be produced year-round and marketed through supermarkets, hotels, restaurants, fitness centres, and other retail outlets. The use of locally available fruits can further improve consumer acceptance and product identity.
- The economic advantage of whey-based products lies in the low raw material cost, since whey is a by-product of dairy processing. Major production costs include whey collection, transportation, ingredients, packaging, processing, and marketing. Consumer awareness, product quality, branding, and compliance with food safety regulations are essential for market success.
- Challenges such as dispersed whey collection, cold-chain requirements, and limited consumer awareness can be addressed through cooperative processing, centralized collection systems, and partnerships with established dairy industries.
- A phased commercialization strategy is recommended, beginning with whey lolly production as a low-investment product, followed by large-scale production of bottled whey beverages. Overall, pineapple-flavoured whey beverage offers the strongest long-term commercial opportunity due to its larger market potential, higher profitability, and wider distribution prospects, while promoting sustainable utilization of paneer whey in Nepal's dairy sector.

CHAPTER VI: CONCLUSIONS

- Nepal's dairy industry generates approximately 75452 metric tons of whey annually, much of which is discarded, causing environmental pollution and economic loss. The study demonstrates that whey is a valuable resource that can be converted into safe, nutritious, and commercially viable food products.
- Physicochemical analysis showed significant variation among whey types. Mozzarella and yak cheese whey contained the highest protein levels, while yak cheese whey had the highest total soluble solids and reducing sugars, indicating that different whey types have different industrial applications.
- Citric acid was identified as the most suitable coagulant for whey lolly production because it produced a clean, pleasant flavour, whereas acetic acid imparted an undesirable pungent taste.
- The optimized whey lolly formulation contained 18% sugar with 10% replacement by 42 DE glucose syrup (90:10 ratio), providing the highest sensory acceptability and desirable physicochemical characteristics.
- The optimized pineapple-flavoured whey beverage was obtained using a 90:10 whey-to-pineapple juice ratio, producing the best sensory quality while meeting microbiological standards at production.
- Shelf-life evaluation showed that the whey beverage remained microbiologically safe for 60 days under refrigeration (4–8°C) and 30 days at room temperature, with gradual sensory deterioration during storage.
- The developed whey products demonstrated strong potential for commercialization. The whey beverage offers greater scalability and profitability, while whey lolly provides an attractive value-added option for small dairy enterprises and cooperatives.
- Overall, the study confirms that converting whey into value-added products can reduce environmental pollution, improve resource utilization, create additional income for dairy processors, and contribute to the sustainable development and circular bio economy of Nepal's dairy sector.

CHAPTER VII: RECOMMENDATIONS

The study has the following recommendations

- Standardize citric acid as the preferred coagulant for paneer and chhena production when whey is intended for value-added products, as it provides better flavour and product quality.
- Improve whey collection and handling by installing stainless steel collection tanks, chilling facilities, and insulated transport systems. Whey should be cooled below 10°C within two hours of production to maintain quality.
- Promote pilot-scale whey lolly production at dairy cooperatives using the optimized formulation as a low-cost value-added product for local markets, schools, and tourist areas.
- Commercialize the pineapple-flavoured whey beverage using the optimized formulation through pilot bottling facilities, targeting urban consumers, hotels, fitness centers, and retail markets.
- Expand product development by introducing new fruit-flavoured whey beverages (e.g., mango, lemon, passion fruit, and indigenous fruits) and developing probiotic whey drinks to increase product diversity and market value.
- Ensure compliance with food safety regulations by registering products with DFTQC, following proper labeling requirements, implementing routine microbiological monitoring, and conducting further research on shelf-life extension through advanced processing and packaging technologies.
- Strengthen policy support by developing a national whey utilization policy, discouraging untreated whey disposal, providing subsidies for whey-processing equipment, and promoting consumer awareness of whey-based products through coordinated campaigns.
- Undertake further research on seasonal variation in whey composition, detailed techno-economic feasibility and cost-benefit analysis, and nutritional bioavailability of whey proteins and minerals to support large-scale commercialization and health claims.

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ANNEXES

Annex 1

Study Team

क्र. सं	नाम	ठेगाना	पद
१	श्री डा. हसना मैया श्रेष्ठ	निर्देशक (प्रा), रा.दु.बि.बोर्ड	संयोजक
२	श्री डा. हुमा कुमारी बखिम	ब. खा. अ.अ, खाद्य प्रबिधि तथा गुण नियन्त्रण बिभाग	बिषय बिशेषज्ञ
३	श्री नारायण देशार	अनुसन्धान अधिकृत,रा.दु.बि.बोर्ड	सदस्य सचिब

Annex 2

राष्ट्रिय दुग्ध बिकास बोर्ड
हरिहरभबन, ललितपुर
Feasibility on innovative product development (whey based product) based on whey बिषयक अध्ययन सम्बन्धी तथ्यांक संकलन फाराम
२०८२

१ उद्योगको नामः
ठेगानाः....................जिल्ला,............गा.पा/ न.पा/म .न.पा.............सम्पर्क नंः

२ बार्षिक बिबरण दिनुहोस

क) दूध संकलन (लिटर): प्रति लिटर दूधको खरिद मूल्यः............................

ख) पनिर उत्पादनः .... के.जी
पनिर उत्पादनमा प्रयोग हुने दूधको गुणस्तरः Fat:..., SNF..., अम्लता........
मिसावट परिक्षणः....................
दूधको आयतनः...............लिटर, छेनाको तौल...के.जी, whey को तौल.......के जी

ग) चीज उत्पादनः .... के.जी
चीज उत्पादनमा प्रयोग हुने दूधको गुणस्तरः Fat:..., SNF........, अम्लता........
मिसावट परिक्षणः....................
दूधको आयतनः.......लिटर, छेनाको तौल........के.जी, whey को तौल........ के जी

घ) छुर्पी उत्पादनः .... के.जी
छुर्पी उत्पादनमा प्रयोग हुने दूधको गुणस्तरः Fat:......., SNF....., अम्लता........
मिसावट परिक्षणः....................
दूधको आयतनः.......लिटर, छेनाको तौल........के.जी, whey को तौल........ के जी

३ पनिर/ छुर्पी / चीजको whey कति उत्पादन हुन्छ र के गर्नुहुन्छ?

४ whey को बिबरण

क) रंग:......................

ख) स्वाद:.......................

५ पनिर/ छुर्पी / चीज उत्पादनको Flow chart दिनुहोस

दूध संकलन

↓

Standardization (Fat:….., SNF………., acidity……………..)

↓

Pasteurization(Temperature………………., holding time……………..)

↓

Curdling: Temperature………, Acid used:……………, Concentration……………
Culture used……………..Concentration……………

↓ ↘

ह्वे
Acidity:
Total Solid:
Weight:

चीज/ पनिर/छुर्पी
तौल:

तथ्यांक लिने	तथ्यांक दिने
नाम थर:	नाम थर:
पद:	पद:
रा. दु.बि.बोर्ड:	संस्थाको नाम:
दस्तखत:	दस्तखत:
मिति:	मिति:

Annex 3

Dairy farms/ industries for whey sample and data collection

S.No	Dairy Industry, Farm Name	District	Whey Type
1	Dadhuwa Chaury Farm	Ramechhap	Chhurpi
2	Sailung Krisi Chaury Farm	Ramechhap	Chhurpi
3	Bhalukhop Tendy Chaury Farm	Solukhumbu	Chhurpi
4	Tendy chaury farm	Solukhumbu	Chhurpi
5	Dolakha Dugdha Udhyog	Dolakha	Chhurpi
6	Yak Cheese Centre , Chordung	Dolakha	Yak Cheese
7	Yak cheese centre , Thodung	Ramechhap	Yak Cheese
8	kanchan Dudh Dairy Pvt.Ltd	Kavre	Paneer
9	Galphu Binayak Dairy Pvt. Ltd	Kavre	Paneer
10	DDC Paneer Production Centre	Kavre	Paneer
11	Sarbahitaisi Dairy and Agrovet Research Centre Pvt Ltd	Kavre	Paneer
12	Anup Dairy Udhyog Pvt .Ltd	Kavre	Paneer
13	Mata Manakamana Dairy Udhyog Pvt . Ltd	Kavre	Paneer
14	Suvaramva Dairy and Agrovet Research Centre pvt. Ltd	Kavre	Paneer
15	Okhaldhunge dairy and Agrovet Research Centre pvt. Ltd	Kavre	Paneer
16	Country Foods Pvt. Ltd	Bhaktapur	Paneer
17	Kalika dairy Pvt.Ltd	Bhaktapur	Paneer
18	Gaytri Dairy	Makwanpur	chhurpi
	Gaytri Dairy	Makwanpur	chhurpi
	Gaytri Dairy	Makwanpur	chhurpi
19	Subha Dairy Pvt.Ltd	Makwanpur	chhurpi
	Subha Dairy Pvt.Ltd	Makwanpur	chhurpi
	Subha Dairy Pvt.Ltd	Makwanpur	chhurpi

	Subha Dairy Pvt.Ltd	Makwanpur	chhurpi
20	Hetauda Dairy Industries	Makwanpur	paneer
21	Mankamana Dudh Parsodhan tatha utpadan Udhyog	Makwanpur	paneer
	Mankamana Dudh Parsodhan tatha utpadan Udhyog	Makwanpur	Chhurpi
22	Rivera Dairy Farm	Makwanpur	Mozeralla
23	Jilla Dugdha Utpadak Sahakari Sangh	Makwanpur	paneer
24	Lucky Dairy	Ilam	Paneer
	Lucky Dairy	Ilam	Kanchan cheese
25	Sundar Dairy	Ilam	Kanchan Cheese
26	Panchamrit Dairy	Ilam	Kanchan Cheese
27	Kusang Dairy	Ilam	Kanchan Cheese
28	Binayak Dairy	Ilam	Kanchan Cheese
29	Niranjan Dairy	Ilam	Kanchan Cheese
30	Anamol Cheese Udhyog	Ilam	Kanchan Cheese
31	Haleshi Dairy Udhyog	Ilam	Chhurpi
32	Anuradha Dairy Pvt Ltd	Ilam	Kanchan Cheese
33	Ritika Dairy	Jhapa	Paneer
	Ritika Dairy	Jhapa	Chhurpi
34	NMC Dairy Udhyog	Jhapa	Paneer
35	Kanchan jangha Dairy	Ilam	Chhurpi
36	Yak Cheese Centre, DDC	Rasuwa, Dhunchhe	Yak Cheese
37	Yak Cheese Centre, DDC	Rasuwa, Chandanbari	Yak Cheese
38	Yak Cheese Centre, DDC	Rasuwa, Lantang	Yak Cheese
39	Yak Cheese Centre, DDC	Rasuwa, Gatlang	Yak Cheese

40	Yak Cheese Centre, DDC	Rasuwa, Tatopani	Yak Cheese
41	Himali Dairy Centre	Nuwakot	Mozeralla
42	Raila Dairy Centre	Nuwakot	Mozeralla
43	Kalika Dairy Centre	Nuwakot	Mozeralla
44	Jay shree Arjun Dairy Centre	Nuwakot	Mozeralla
45	Nuwakot Dairy Centre	Nuwakot	Mozeralla
46	Himalayan French Cheese Pvt Ltd	Kavre	Mozerrella
47	Himal farm	Lalitpur	Mozerrella

Annex 4

राष्ट्रिय दुग्ध बिकास बोर्ड
हरिहरभबन, ललितपुर

भुइकटहर स्वादको ह्वे ललिको इण्ड्रियगत मुल्यांकन

९ अंकिय हेडोनिक मूल्यांकन परीक्षण

मूल्यांकनकर्ताको नाम: मिति:

कृपया प्रदान गरिएको उत्पादन अबलोकन गर्नुहोस र प्रतिक्रिया वा टिप्पणीहरुसहित उत्पादनको बारेमा तपाईको भाबनाहरुलाई उत्तम रुपमा वर्णन गर्ने बिन्दुमा बिश्लेषण गरेर आफ्नो राय देखाउन उपयूक्त स्केल प्रयोग गर्नुहोस ।

अति उत्तम	९	ठिकै लाग्यो	६	मध्यम मन पर्दैन	३
धेरै मन प-यो	८	न मन प-यो न मन परेन	५	असाध्यै मन परेन	२
मध्यम लाग्यो	७	अलिकति मन परेन	४	अत्ति नै मन परेन	१

Parameters / Sample Code	Flavour	Sweetness	mouth feel	Aroma
T1				
T2				
T3				
T4				

Annex 5

Effect of sugar variation on sweetness score of lolly								
Formulations	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
T1	15	6.87	0.352	0.091	6.67	7.06	6	7
T2	15	7.53	0.516	0.133	7.25	7.82	7	8
T3	15	5.53	0.516	0.133	5.25	5.82	5	6
Total	45	6.64	0.957	0.143	6.36	6.93	5	8
Anova Result	F value =71.014/P value= 0.000							

Annex 6

Effect of sugar variation on mouth feel score of lolly								
Formulations	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
T1	15	6.87	0.743	0.192	6.46	7.28	6	8
T2	15	8.00	0.378	0.098	7.79	8.21	7	9
T3	15	4.33	0.976	0.252	3.79	4.87	3	6
Total	45	6.40	1.711	0.255	5.89	6.91	3	9
Anova Result	F value=96.26/P value=0.000							

Annex 7

Effect of sugar variation on flavor score of lolly								
Formulations	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
T1	15	5.27	0.594	0.153	4.94	5.60	4	6
T2	15	7.53	0.516	0.133	7.25	7.82	7	8
T3	15	4.53	0.516	0.133	4.25	4.82	4	5
Total	45	5.78	1.396	0.208	5.36	6.20	4	8
Anova Result	F value=124.269/P value=0.000							

Annex 8

Effect of sugar variation on aroma score of lolly								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
T1	15	6.93	0.458	0.118	6.68	7.19	6	8
T2	15	7.00	0.378	0.098	6.79	7.21	6	8
T3	15	4.27	0.799	0.206	3.82	4.71	3	5
Total	45	6.07	1.405	0.209	5.64	6.49	3	8
Anova Result	F value=110.452/P value=0.000							

Annex 9

Effect of sugar and glucose syrup variation on sweetness score of lolly								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
G1	15	5.60	0.507	0.131	5.32	5.88	5	6
G2	15	6.53	0.516	0.133	6.25	6.82	6	7
G3	15	8.00	0.378	0.098	7.79	8.21	7	9
G4	15	7.93	0.458	0.118	7.68	8.19	7	9
Total	60	7.02	1.112	0.144	6.73	7.30	5	9
Anova Result	F value=92.395/ P value= 0.000							

Annex 10

Effect of sugar and glucose syrup variation on mouth feel score of lolly								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
G1	15	5.40	0.632	0.163	5.05	5.75	4	6
G2	15	6.93	0.458	0.118	6.68	7.19	6	8
G3	15	8.00	0.000	0.000	8.00	8.00	8	8
G4	15	7.00	0.756	0.195	6.58	7.42	6	8
Total	60	6.83	1.076	0.139	6.56	7.11	4	8
Anova Result	F value=58.484/P=0.000							

Annex 11

Effect of sugar and glucose syrup variation on flavour score of lolly								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
G1	15	5.33	0.488	0.126	5.06	5.60	5	6
G2	15	6.47	0.516	0.133	6.18	6.75	6	7
G3	15	7.93	0.458	0.118	7.68	8.19	7	9
G4	15	7.47	0.516	0.133	7.18	7.75	7	8
Total	60	6.80	1.117	0.144	6.51	7.09	5	9
Anova Result	F value=81.372/ P value= 0.000							

Annex 12

Effect of sugar and glucose syrup variation on aroma score of lolly								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
G1	15	4.47	0.640	0.165	4.11	4.82	4	6
G2	15	5.40	0.507	0.131	5.12	5.68	5	6
G3	15	7.93	0.458	0.118	7.68	8.19	7	9
G4	15	6.27	0.594	0.153	5.94	6.60	5	7
Total	60	6.02	1.396	0.180	5.66	6.38	4	9
Anova Result	F value=106.121/ P value=0.000							

Annex 13

राष्ट्रिय दुग्ध बिकास बोर्ड
हरिहरभवन, ललितपुर

भुइकटहर स्वादको ह्वे बेभरेजको इण्ड्रियगत मुल्यांकन

९ अंकिय हेडोनिक मूल्यांकन परीक्षण

मूल्यांकनकर्ताको नामः मितिः

कृपया प्रदान गरिएको उत्पादन अबलोकन गर्नुहोस र प्रतिक्रिया वा टिप्पणीहरुसहित उत्पादनको बारेमा तपाईको भाबनाहरुलाई उत्तम रुपमा वर्णन गर्ने बिन्दुमा बिश्लेषण गरेर आफ्नो राय देखाउन उपयूक्त स्केल प्रयोग गर्नुहोस ।

अति उत्तम	९	ठिकै लाग्यो	६	मध्यम मन पर्दैन	३
धेरै मन प-यो	८	न मन प-यो न मन परेन	५	असाध्यै मन परेन	२
मध्यम लाग्यो	७	अलिकति मन परेन	४	अत्ति नै मन परेन	१

Parameters / Sample Code	Flavour	Sweetness	mouth feel	Aroma
F1				
F2				
F3				
F4				

Annex 14

Effect of whey and pineapple juice variation on sweetness score of beverage

Formulations	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
F1	15	6.80	0.676	0.175	6.43	7.17	6	8
F2	15	7.27	0.458	0.118	7.01	7.52	7	8
F3	15	7.67	0.488	0.126	7.40	7.94	7	8
F4	15	4.00	0.378	0.098	3.79	4.21	3	5
Total	60	6.43	1.533	0.198	6.04	6.83	3	8
Anova Result	F value=157.903/P value= 0.000							

Annex 15

Effect of whey and pineapple juice variation on mouth feel score of beverage								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
F1	15	7.53	0.640	0.165	7.18	7.89	6	8
F2	15	7.47	0.516	0.133	7.18	7.75	7	8
F3	15	8.00	0.378	0.098	7.79	8.21	7	9
F4	15	4.07	0.458	0.118	3.81	4.32	3	5
Total	60	6.77	1.661	0.214	6.34	7.20	3	9
Anova Result	F value=192.284/P value=0.000							

Annex 16

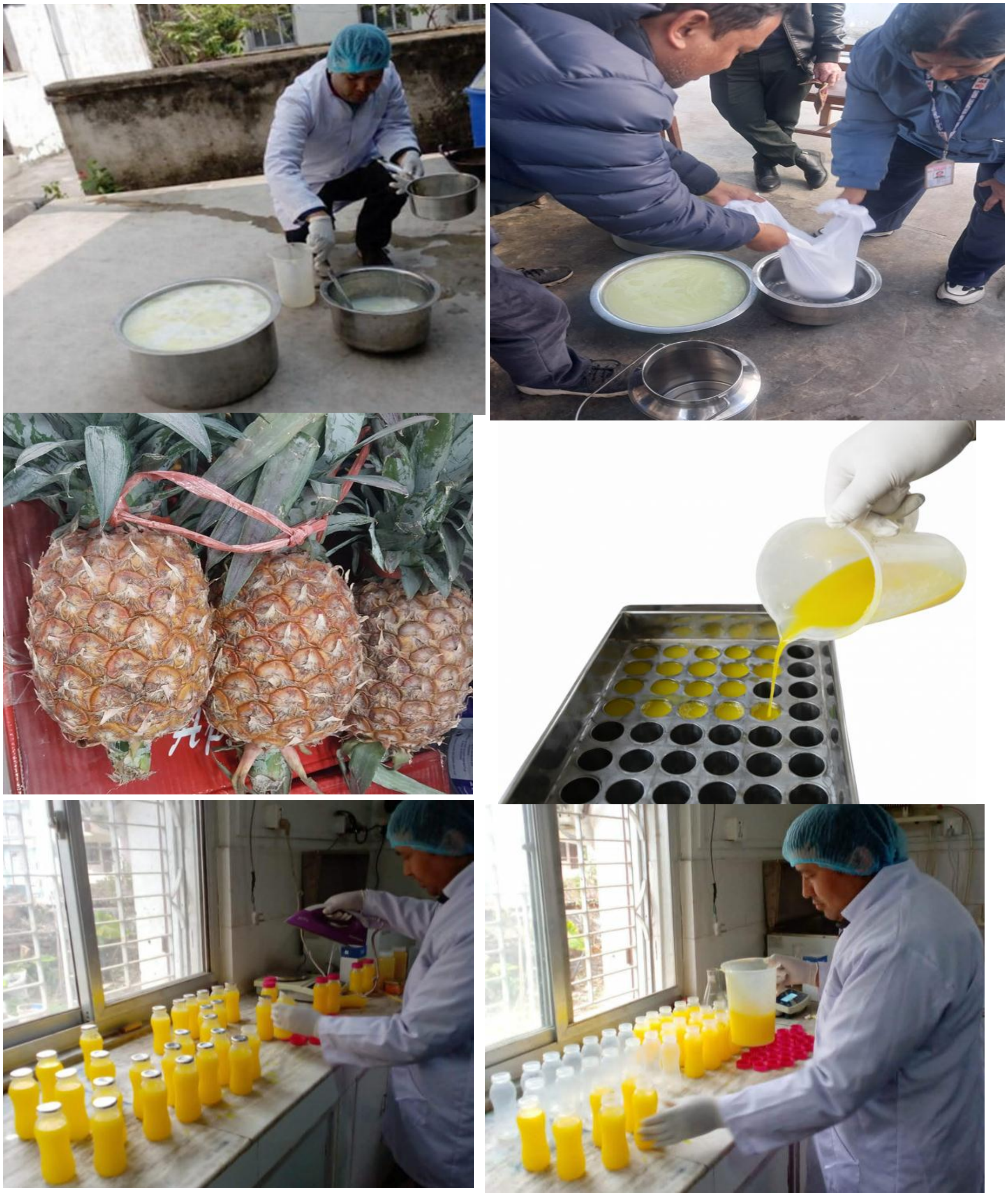
Effect of whey and pineapple juice ratio in flavour score of beverage								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
F1	15	7.80	0.414	0.107	7.57	8.03	7	8
F2	15	7.33	0.617	0.159	6.99	7.68	6	8
F3	15	8.00	0.535	0.138	7.70	8.30	7	9
F4	15	4.00	0.000	0.000	4.00	4.00	4	4
Total	60	6.78	1.698	0.219	6.34	7.22	4	9
Anova Result	F value=252.080/P value= 0.000							

Annex 17

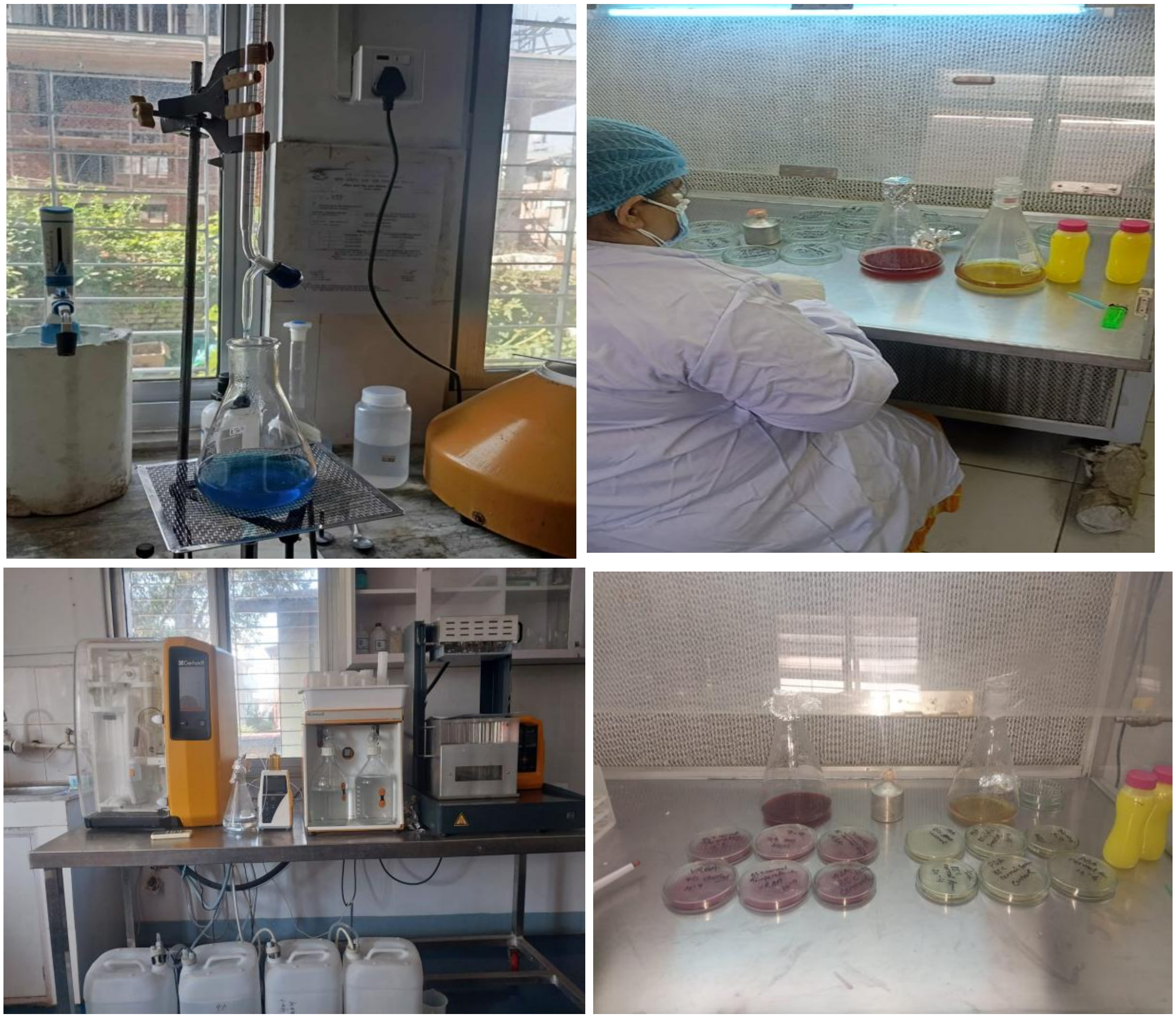
Effect of whey and pineapple juice ratio in aroma score of beverage								
					95% Confidence Interval for Mean			
Formulations	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
F1	15	7.93	0.258	0.067	7.79	8.08	7	8
F2	15	7.27	0.458	0.118	7.01	7.52	7	8
F3	15	8.00	0.000	0.000	8.00	8.00	8	8
F4	15	4.00	0.000	0.000	4.00	4.00	4	4
Total	60	6.80	1.675	0.216	6.37	7.23	4	8
Anova Result	F value=780.782/P value= 0.000							

Some pictures

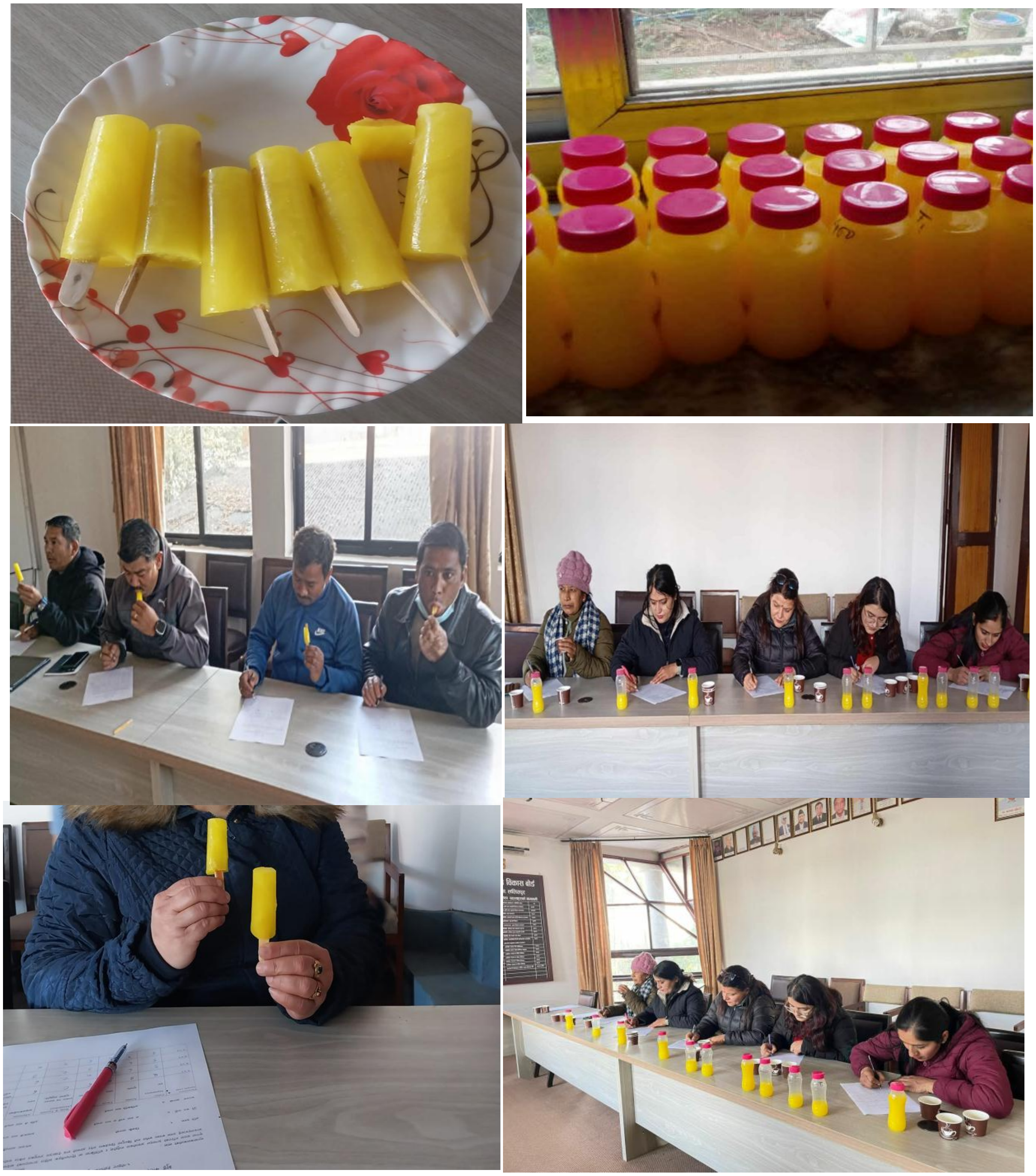
Field Survey and Sample Collection



Whey Lolly and Beverage Preparation(NDDB)



Physico-chemical and Microbiological Testing (NDDB Lab)



Whey Lolly and Beverage Sensory Evaluation